# AIR FORCE

# QUALIFICATION TRAINING PACKAGE (AFQTP)


**for**

**ELECTRICAL SYSTEMS**
**(3E0X1)**

## MODULE 17

## UNDERGROUND DISTRIBUTION SYSTEMS

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## MODULE 17

## UNDERGROUND DISTRIBUTION SYSTEMS



Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

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# AIR FORCE QUALIFICATION TRAINING PACKAGES
**for**
**ELECTRICAL SYSTEMS**
**(3E0X1)**

## INTRODUCTION

*Before starting this AFQTP,* **refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site** http://www.afcesa.af.mil/. This guide will be found at each AFS's AFQTP download page.

***AFQTPs are mandatory and must be completed*** to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

***AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks***.

### MANDATORY minimum upgrade requirements:

***Core task:***
AFQTP completion
Hands-on certification

***Diamond task:***
AFQTP completion
CerTest completion (80% minimum to pass)

***Note:*** *Trainees will receive hands-on certification training when equipment becomes available either at home station or at a TDY location.*

***Put this package to use.*** Subject matter experts under the direction and guidance of HQ AFCESA/CEOT revised this AFQTP. If you have any recommendations for improving this document, please contact the Electrical Career Field Manager at the address below.

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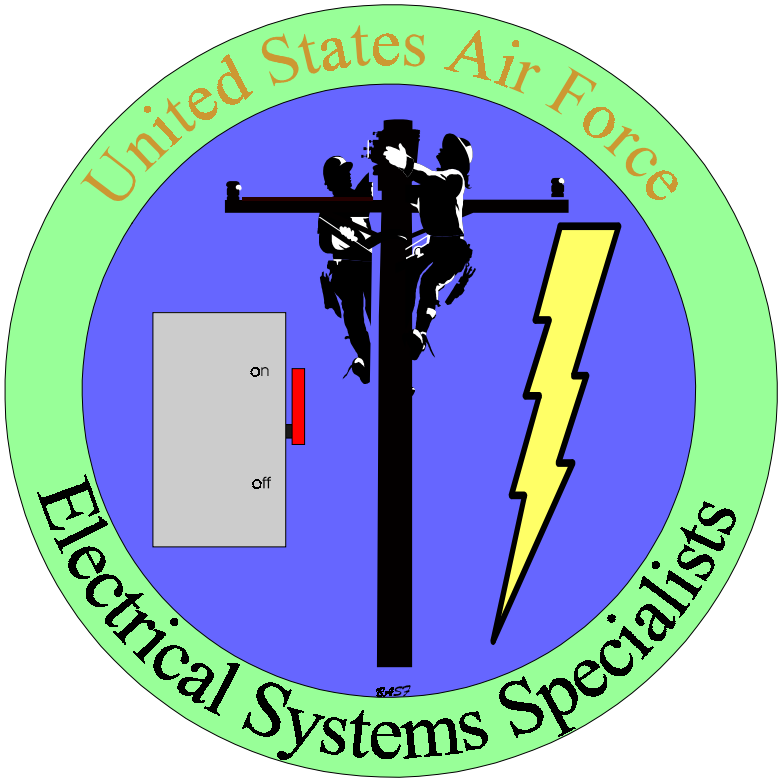
**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.




# INSTALL

## MODULE 17 AFQTP UNIT 1

## DIRECT BURIAL CABLE (17.1.1.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

# DIRECT BURIAL CABLE
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | 17.1.1. – Underground distribution systems, install direct burial cable |
| **Training References:** | • 17.1.1.Video (Install Direct Burial Cable)<br>• CDC 3E0X1 Set B Vol. 3<br>• Lineman's and Cableman's Handbook |
| **Prerequisites:** | • Possess as a minimum a, 3E031 AFSC. |
| **Equipment/Tools Required:** | • Trencher<br>• Cable<br>• Shovels<br>• Marking tape<br>• Personal Protective Equipment |
| **Learning Objective:** | • Given equipment, install direct burial cable |
| **Samples of Behavior:** | • Follow approved methods to install direct burial cable<br>• Know safety requirements for installing direct burial cable |
| **Notes:** | |
| • Any safety violation is an automatic failure. | |

## DIRECT BURIAL CABLE

**Background:** While use of underground cable is not new, in the past it was normally restricted to short runs in highly congested urban areas where overhead distribution was not practical. Recent developments in sheath materials, as well as better insulation materials, have produced lighter, more reliable cable. This fact, coupled with increased overhead costs and increased opposition from environmentalist groups, has brought about more and more underground transmission and distribution cable systems.

**Direct burial cable.**

- The three ways to install direct burial cables are trenching, plowing, and shooting or burrowing.
- When using a trencher, the spacing of the teeth and the length of the chain determine the width and the depth that the trench will be dug.

**SAFETY:**
**USING A TRENCHER AROUND EXISTING POWER, PHONE, FIBER, AND WATER LINES CAN BE HAZARDOUS. THE TRENCHERS DIGGING CAPABILITY CAN EASILY SEAVER THESE UTILITY LINES.**

- For installations requiring multiple runs of cable or more than one cable, a backhoe will provide a wider trench.

**NOTE:**
Measure the level of the trench throughout the excavation, to ensure the trench is level.

- Avoid unnecessary jostling of cable during the installation to avoid damage.

**SAFETY:**
**REMAIN CLEAR OF ALL MOVING PARTS OF DIGGING EQUIPMENT DURING EXCAVATION, TO PREVENT ACCIDENTAL INJURY.**

- All cable installation must be properly identified with marking tape.
- Marking tape is placed one foot from the surface of the trench.

***To perform the task, view video:*** **17.1.1.V: (Underground Cable Installation).**

**NOTE:**
During the video the spokesperson will direct you to review the segment of the video covered and to answer the questions at the end of the unit. Disregard those statements and view the video in its entirety. Special attention should be focused to Section 1. Direct Burial of URD Cable. After the video has been viewed, return to the QTP, review the steps listed below and answer the review questions.

**Step 1:** Run digging permit then hand dig to expose any thing that could be cut or damaged.
**Step 2:** Use trencher or backhoe and dig trench to desired length and depth.
**Step 3:** Back fill a 3 inch layer of sand in bottom of trench, this will act as a bedding material for the cable.
**Step 4:** Lay cable into trench.
**Step 5:** Back fill an additional 3 inches of sand on top of cable, this will help protect the cable from rocks and other debris.
**Step 6:** Back fill trench to with-in one foot of top with soil.
**Step 7:** Lay in marking tape the length of the trench.
**Step 8:** Finish back filling remaining soil over trench.

# Review Questions
# for
# Direct Burial Cable

| Question | Answer |
|---|---|
| 1. What should be the first step in installing direct buried cable? | a. Hand dig<br>b. Run digging permit<br>c. Check out equipment |
| 2. When using a trencher, what determines the width and the depth that the trench will be dug? | a. The spacing of the teeth.<br>b. The length of the teeth<br>c. The length of the chain<br>d. A and C |
| 3. The use of trenchers around power, phone fiber, and water lines are encouraged in rocky areas only. | a. True<br>b. False |
| 4. What installation equipment is used when multiple utility lines are installed in one trench? Could use trencher also. | a. Trencher<br>b. Cable Plow<br>c. Bullet<br>d. Backhoe |
| 5. During installation worker should remain clear of _____, to prevent accidental injury. | a. Backhoe bucket<br>b. Trencher Chain<br>c. Plow Channel<br>d. All of the above |
| 6. All cable installations must be properly identified with marking tape. | a. True<br>b. False |

**DIRECT BURIAL CABLE**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Did trainee know the three basic methods of installation direct burial cable? | | |
| 2. Did trainee investigate to see if any power, phone, fiber, or water lines were in the area to install cable? | | |
| 3. Did trainee check trench to ensure it was level throughout the excavation? | | |
| 4. Was a 3-inch layer of sand placed above and below the cable? | | |
| 5. Did trainee remain clear of all moving parts on the digging equipment? | | |
| 6. Did trainee properly identify all cables with marking tape? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.


# INSTALL

**MODULE 17** **AFQTP UNIT 1**

## TRANSFORMER PADS (17.1.3.1.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

**INSTALL TRANSFORMER ON PAD**

## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | 17.1.3.1 Install transformer on pad |
| **Training References:** | • CDC 3E051B, VOL1<br>• Lineman's and Cablemans Handbook |
| **Prerequisites:** | • Possess as a minimum 3E031 AFSC<br>• Completed AFQTP Module 17 Unit 5 or 10 (which ever applies to your situation)<br>• Pad must be already properly sized and installed<br>• Primary and secondary cables are already installed<br>• Read AFQTP Module 11 for lock out/tag out and for interpreting AF Form 269 when performing switching<br>• Read AFQTP Module 17 for terminating cable |
| **Equipment/Tools Required:** | • Pad-mounted transformer<br>• Line truck or equivalent<br>• Electricians handtools<br>• Anchors if necessary<br>• High voltage source<br>• Terminations<br>• Lifting devices |
| **Learning Objective:** | • Given the necessary equipment, install a pad-mounted transformer |
| **Samples of Behavior:** | • Follow approved methods and install a pad-mounted transformer<br>• Know safety requirements for installing pad-mounted transformer |
| **Notes:** | |
| • Any safety violation is an automatic failure. | |

## INSTALL PAD-MOUNTED TRANSFORMER

**BACKGROUND:** Pad mounted transformers are used to provide underground service and can be fed from an overhead or underground source. Exterior pad-mounted transformers should be installed as close to the building served as permissible and as near as practicable to the secondary distribution center. This will help keep line loss and the installation cost to a minimum. If the primary service is from an overhead system, locate the medium voltage riser pole as close as practicable to the transformer. If the service is being fed from an underground source, pick the manhole closest to the transformer location.

**Step 1** - Select lifting device of proper weight capacity

The most common devices used are steel cables, straps or chains. It is important to ensure the lifting devices used to position the transformer are able to handle the weight of the transformer.

**Step 2** – Select proper equipment for positioning and lifting of the transformer

Forklift, line truck, or crane are some of the more common heavy equipment items used for positioning and lifting. If the transformer is too heavy for a line truck or forklift to handle, assistance from heavy equipment may have to be obtained.

**Step 3 –** Ensure facility main breaker/disconnect is open following proper locking and tagging procedures. This will prevent any possible back feed and will protect the facility equipment when checking voltage and phase rotation (if 3 phase) after initial energizing of new transformer after installation. Refer to AFQTP Module 11 for lock-out/tag-out.

**Step 4** - Position the transformer on the pad

Keep the transformer as close to the ground as possible to keep personnel from walking under it and to reduce possible damage to the transformer and/or equipment if it were to fall. Position the transformer on the pad and ensure it is in the direction intended (high voltage cabinet over the high voltage conduits). Extra care should be taken to protect the cables when lowering the transformer. After the transformer is in place, check the pad to make sure that the additional weight of the transformer has not caused the pad to settle unevenly.

**Step 5** - Anchor transformer if necessary

**Step 6** - Make transformer connections

When making connections, the first connection is always ground. Ensure the case and secondary grounds are connected to a reliable grounding electrode (normally a grounding rod). Refer to AFQTP Module 17 for terminating cable.

**Step 7** - Energize transformer

Refer to AFQTP Module 11 for interpreting AF Form 269 when performing switching.

**Step 8** - Take secondary voltage reading and check phase rotation (if 3 phase). This is done prior to closing the main breaker to ensure the voltage and phase rotation is correct. If the voltage or rotation is incorrect, damage to the facility equipment may occur. If the secondary voltage is incorrect, adjust the taps according to local specifications. If the phase rotation is incorrect, swap any two current carrying conductors. These conductors can be moved at either the transformer or main breaker/disconnect

**Step 9** - Close main breaker/disconnect and take another secondary voltage reading to ensure you have the required voltage after the load has been applied. Occasionally

when applying a load, the voltage may drop and have to be readjusted. If the voltage drops beyond acceptable parameters, reopen facility main breaker/disconnect, de-energize transformer and readjust taps. If transformer has to be readjusted, repeat readings after closing all circuits.

**Step 10** - Clean up job site

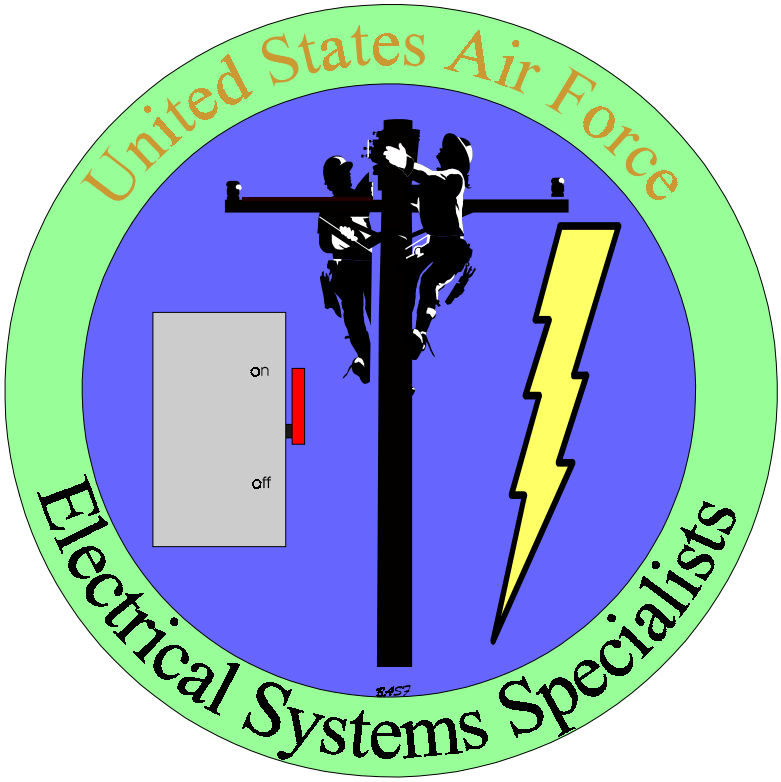
# Review Questions
# for
# Install Pad-mounted Transformer

| Question | Answer |
|---|---|
| 1. Transformer location should be as close to the facility for what reason(s)? | a. So that it looks better<br>b. To make the secondary run shorter<br>c. To help keep line loss and cost to a minimum<br>d. To help prevent capacitance and keep the cost to a minimum |
| 2. What should be done to the lifting device prior to lifting the transformer? | a. Tape frayed ends<br>b. Cleaned with warm soapy water<br>c. Checked for proper weight capacity<br>d. Be inspected by the electrical superintendent |
| 3. What should be checked after the transformer is placed on the pad? | a. KVA and voltage rating<br>b. Nomenclature for the transformers weight<br>c. The pad to ensure the pad did not settle unevenly<br>d. The high voltage and secondary compartments for proper positioning |
| 4. What should be done after all connections are made to the primary and secondary? | a. Energize the transformer for testing<br>b. Make all ground connections<br>c. Anchor the transformer to the pad<br>d. Close the facilities main breaker |
| 5. What should be accomplished after the transformer is energized? | a. Make all ground connections<br>b. Check secondary voltage and phase rotation<br>c. Close main breaker<br>d. Clean-up job site |

**PAD-MOUNTED TRANSFORMER**

| **Performance Checklist** | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Did the trainee lock out/tag out facility's main breaker/disconnect prior to the installation of the pad-mounted transformer? | | |
| 2. Did the trainee properly position the transformer on the pad without damaging the primary and secondary cable? | | |
| 3. Did the trainee make all primary and secondary connections to the transformer? | | |
| 4. Did the trainee properly test a pad-mounted transformer after installation? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.




# INSTALL

**MODULE 17** **AFQTP UNIT 1**

## GROUNDING SET (17.1.3.3.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

# Install Grounding Set
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | • 17.1.3.3. – Underground distribution systems, install grounding set |
| **Training References:** | • CDC 3E051B VOL3<br>• Lineman's and Cableman's Handbook<br>• AFI 32-1064 Electrical Safe Practices<br>• National Electric Safety Code(NESC)<br>• National Electric Code(NEC) |
| **Prerequisites:** | • Possess as a minimum a, 3E031 AFSC |
| **Equipment/Tools Required:** | • Grounding Set<br>• Personal Protective Equipment<br>• Rubber Protective Equipment<br>• Hand Tools |
| **Learning Objective:** | • Given equipment, install grounding set on pad mounted transformer |
| **Samples of Behavior:** | • Follow approved methods while installing grounding set<br>• Know safety requirements for installing grounding set |
| **Notes:** | |
| • Any safety violation is an automatic failure.<br>• Trainer will brief trainee on the components of the particular transformer to be grounded as well as describe operation of the grounding set used. | |

**Background:** The purpose of a grounding set is to ground the high voltage side of transformers to bleed off any stray voltage. This voltage could be from the high voltage cables feeding the transformer or from possible back feeds from the secondary side of the transformer. In either case it is important to removed the voltage and ground the transformer. This is done so that work may be accomplished safely around and on the transformer. Grounding sets will have four connection points, three will connect to the transformer while the fourth will connect to the system ground or a temporary ground rod. Grounding sets will have one of three types of connectors: an elbow type or grounding clamp type. Each has similar procedures for installation. Each will be covered in this training package.

**Grounding equipment in partially energized substations and vaults.**

It is often impractical to leave the equipment being worked on grounded. In the case of indoor equipment, it may be possible to permanently ground the equipment on the outside. This would be possible where oil circuit breakers are being inspected one at a time with disconnects open between the circuit breaker and the bus. By grounding on the outside and closing the oil circuit breaker, everything in the bay is grounded. In other instances, it may be practical to ground on the deenergized side of the open disconnects. Care must be taken to avoid confusion in tracing out the feeder being worked on between the outside and inside construction. Where the feeder is grounded on the outside, the equipment to be worked on should be checked with an approved high voltage testing device and then grounding cables attached before touching it. Where it is practical to leave the equipment grounded while work is in progress, it is mandatory that each phase of the equipment to be worked on is tested to see that it is de-energized and then touched with a grounded cable before the work begins. This should be done even though all disconnects or other devices for clearing the equipment or jumpers to be worked on are in plain view.

***To perform this task, follow these steps:***

**Step 1: Inspect ground set.**

The ground set should be inspected to ensure that all the connectors work properly and that the grounding conductor and connectors used are the proper size. The grounding conductor should be inspected for cracked or splitting insulation and tight connection to the connectors.

**SAFETY:**
**THE GROUNDING SET SHOULD BE ABLE TO HANDLE THE MAXIMUM FAULT CURRENT THE SOURCE CAN SUPPLY TO THE JOB LOCATION.**

**NOTE:**
The cable to connector connection for the elbow type set may not be visible however they may be checked with an ohmmeter.

**Step 2: Inspect the system ground.**

The system ground should be checked for loose connections, signs of corrosion, and room to place the grounding conductor.

**NOTE:**
If the transformer's system ground is too cluttered or if there is not enough space to make the connection a temporary ground rod must be used.

**NOTE:**
If the transformer has a primary and a secondary bonded ground either may be use.

**Step 3: Clean contact points.**

Clean the area on the ground with a wire brush to remove any oxidation and dirt that may cause poor connection with the grounding set. Clean the contact point or closing jaws of the clamp with the wire brush. All four connectors should be cleaned at this time.

**NOTE:**
The contact pin on the elbow type should be visibly inspected, cleaning with a wire brush may not be possible.

**Step 4: Connect set to ground.**

The first connection made is to the ground point (ground rod). The three other ends should be laid out so that they are not to close to the cables feeding the transformer.

**Step 5: De-energize the transformer.**

**NOTE:**
Prior to making any connection to the transformer inspect it to see what type of primary connections are used, is it feed through, is it switched, look at the data plate. This will determine the accessories needed to properly ground the transformer.

- Isolate the secondary feed from the building by opening the main breaker or switch.
- Open the primary fuses or primary switch on the transformer if installed.
- Isolate the primary feeding the transformer. Opening the feed from its source (i.e. fuses, vacuum switch, or air break switch) does this.

**NOTE***:*
Feed through transformers can be fed from two sources and both feeds will need to be isolated.

- Test for primary voltage by using a high voltage phase tester (Phasing set or audible noise tester).
- Test the secondary for voltage using an appropriate voltage tester or meter.

**NOTE:**
All testers and meters should be checked for proper operation on a known energized circuit prior to being used on de-energized circuits and reverified after use to ensure that they have not been damaged.

**N** n
tra

**NOTE:**
Testing the secondary side of the transformer is important because of possible back-feed from another power source (a generator in a different section of the building). With the primary switch or fuses for that transformer open you may not see the back-feed on the primary side when you check it for voltage.

**NOTE:**
If the transformer has load-break-elbows with the capacitor button you will be able to check for voltage by removing the cap with a universal grip-all stick and placing the tester against the metal button. If using the capacitive type phase tester your reading will be slightly lower than normal for the voltage used on your installation

**Step 7: Connect grounds.**
**Dead Front Transformers.**

- Connect the remaining connectors one each to a primary bushing of the transformer.

**NOTE:**
Care must be taken when making the connection not to pull down too hard on the bushings, this could break the seal, causing a leak, or break the bushing.

**NOTE:**
When making the connection use the appropriate hot stick , there will be a small arch when first contact is made. This is bleeding the residual voltage off the cables and can hurt or kill if not properly protected against.

**Live Front Transformers.** Place the grounding elbows one each on the feed-through bushing and close the feed through switch if present. If feed through bushing are not present or in use the input cables should be removed from the transformer bushings and placed on two way parking bushings. Next the grounding elbows are place on the two way parking bushing to ground the in put cables, then on the transformer bushing elbow to ground it.

# Review Questions
# For
# Install Grounding Set

| Question | Answer |
|---|---|
| 1. The grounding conductors are inspected for _____. | a. Cracked insulation with loose connections.<br>b. Splitting insulation and loose connections.<br>c. Cracked or splitting insulation and loose connections.<br>d. Cracked or splitting insulation and tight connections. |
| 2. What is used to clean the contact surfaces of the ground rod and the connector? | a. Sand paper<br>b. A wire brush<br>c. A rat-tail file<br>d. Chem-wipes |
| 3. What is the grounding set connected too first? | a. The ground.<br>b. The A phase conductor.<br>c. The ground drip on the termination.<br>d. The parking bushing. |
| 4. If the ground rod is to cluttered or inexcessable what is used as a ground point? | a. The transformer case.<br>b. Nothing just lay the ground on the ground.<br>e. The secondary neutral.<br>f. A temporary ground rod. |
| 5. How many sources can a feed through transformer be fed from? | b. 4<br>c. 3<br>d. 2<br>e. 1 |
| 6. What is done after the power has been isolated to a transformer? | a. You should check for continuity.<br>b. You should check for amperage.<br>c. You should check for ohms.<br>d. You should check for voltage. |
| 7. On transformers with one input what should be done with cables that have load-break elbows on them? | a. They should be removed and placed out of the way.<br>b. They should be removed and placed on parking bushings.<br>c. They should be removed and place on double breaking brushes.<br>d. They should be removed and placed on double parking bushings. |

**INSTALL GROUNDING SET**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Can the individual explain the need to ground the transformer? | | |
| 2. When opening the transformer did the individual use proper safety procedures? | | |
| 3. Did the trainee perform an inspection of the grounding set prior to use? | | |
| 4. If needed, were contact points on connectors cleaned with a wire brush? | | |
| 5. Was ground rod inspected for serviceability? | | |
| 6. Was power disconnected from all possible sources? | | |
| 7. Was transformer tested for the lack of voltage prior to grounding? | | |
| 8. Was test equipment verified for proper operation prior to and after checking for voltage? | | |
| 9. Was care taken while handling the bushings so not to damage them? | | |
| 10. Were proper procedures used when removing and placing load-break elbows? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and the trainer.


# SPLICE HIGH VOLTAGE UNDERGROUND CABLE

**MODULE 17** **AFQTP UNIT 3**

## USING TAPE (17.3.1.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

# USING TAPE
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | 17.3.1 – Underground distribution systems, splice high voltage underground cable using tape |
| **Training References:** | • 17.3.1Video (Splice High Voltage UG Cable Using Tape)<br>• CDC 3E0X1, Set B, Vol. 3<br>• Lineman's and Cableman's Handbook |
| **Prerequisites:** | • Possess as a minimum a, 3E031 AFSC. |
| **Equipment/Tools Required:** | • Trenching means<br>• Cable<br>• Shovels<br>• Tape splice kit<br>• General tool kit<br>• |
| **Learning Objective:** | • Given equipment, splice high voltage underground cable |
| **Samples of Behavior:** | • Following approved methods, splice high voltage underground cable<br>• Know safety requirements for splicing high voltage underground cable |
| **Notes:** | |
| • Any safety violation is an automatic failure. | |

## USING TAPE

**Background:** Underground cable is usually either direct burial or installed in ducts. While repair methods are basically the same for any underground cable, there are some differences that depend on the installation condition. The goal of splicing cables is to connect two-cables together maintaining the original cables mechanical and electrical strength.

In most cases, the fault is in either an existing splice or a termination and the repair is comparatively simple. In other cases, though, the fault is in the cable itself and the repair involves removing a defective cable length and splicing in a good length. The replacement must be the same as the original cable or a type of cable that is comparable to and compatible with the original cable. Use splice kits and termination kits as much as possible.

The manufacturer of the cable or the kit used for any specific splice provides detailed instructions. After the repair is completed (and before backfilling for direct-burial cable), make insulation resistance and potential tests to determine that the cable, including the new repair, is suitable for use.

***To perform the task, view video:*** **17.3.1V: (Cable Splicing).**

**VIDEO NOTE:**
During the video the spokesperson will direct you to review the segment of the video covered and to answer the questions at the end of the unit. Disregard those statements and view the video in its entirety. Special attention should be focused to Section 1.3 Cable Preparation and 1.4 Primary Cable Splicing. After the video has been viewed, return to the QTP, review the steps listed below and answer the review questions.

**Step 1. Preparing the cable.**

- **NOTE:**
  Do not damage the layer below the layer being removed. A small nick in the insulation can cause a stress area in the splice.

- Manufacture splice instructions must be followed to ensure that the splice preparation is correct.
- Splice area must be clean and free of dirt and all contaminants; this will prevent any conductive paths that can weaken the integrity of the splice.
- Penciling of the primary insulation is key to providing a transition free of voids from the original insulation too the insulation that will be applied. (The key to eliminate air voids is to stretch the tape)

**Step 2. Making the splice.**

- Manufacture splice instructions must be followed to ensure that the splice is correct.
- The connector or sleeve is the junction where the two cable ends are connected.
- Mechanical and hydraulic crimpers are used to install connector or sleeves on the cable ends.
- Most mechanical and hydraulic crimpers come with interchangeable dies, which are used to crimp various sized cables.
- Some of the tapes used on splices are rubber, semi-conductive, conductive, and plastic.

**NOTE:**
Resin based flux is the only solder allowed for high voltage cable splices.

# Review Questions
# for
# Using Tape

| Question | Answer |
|---|---|
| 1. The goal of splicing cables is to connect two cable ends maintaining the cable's original _____ and _____ strength. | a. Integral, electrical<br>b. Mechanical, electrical<br>c. Electrical, Insulation<br>d. Mechanical, Insulation |
| 2. Penciling of the primary insulation is key to providing smooth a transition from the original insulation and the insulation that will be applied. | a. True<br>b. False |
| 3. What is the junction point where the cable ends are connected? | a. The sleeve<br>b. The connector<br>c. The Crimper<br>d. A and B |
| 4. Most mechanical and hydraulic crimpers come with interchangeable ____, which are used to crimp various sized cables | a. Sleeves<br>b. Connectors<br>c. Dies<br>d. All of the above |
| 5. Only acid base flux will be used on high voltage splices. | a. True<br>b. False |

**USING TAPE**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Did the Trainee follow manufacturer's instructions? | | |
| 2. Did the trainee clean splice area of all dirt and contaminates? | | |
| 3. Does the trainee know the type of crimpers used for making splices? | | |
| 4. Did the trainee use the correct size dies for the cable they are working on? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.


# UNDERGROUND DISTRIBUTION SYSTEMS

**MODULE 17** **AFQTP UNIT 5**

## TERMINATE HIGH VOLTAGE UNDERGROUND CABLE (17.4.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

# TERMINATE HIGH VOLTAGE UNDERGROUND CABLES
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | • 17.4 – Underground distribution systems, terminate high voltage underground cables |
| **Training References:** | • Lineman's and Cableman's Handbook<br>• National Electric Safety Code(NESC)<br>• National Electric Code(NEC) |
| **Prerequisites:** | • Possess, as a minimum a, 3E031 AFSC |
| **Equipment/Tools Required:** | • Termination kit<br>• A four foot section of cable<br>• Personal Protective Equipment<br>• Hand Tools |
| **Learning Objective:** | • Given equipment, install a termination on high voltage cables |
| **Samples of Behavior:** | • Following approved methods, fabricate a termination on high voltage cables<br>• Know the safety requirements for terminating high voltage cables |
| **Notes:** | |
| • Any safety violation is an automatic failure<br>• Trainer will brief trainee on the components of the particular termination kit used as well as the type of cable to be terminated | |

**Background:** A termination is a transition between the cable and a piece of line equipment. This transition is needed to contain and dissipates the corona effect that is associated with high voltage power cables. Without a proper termination or transition the corona effect will deteriorate the cable causing eventual failure and subsequent replacement. In this unit we will look at the different types of terminations as well as the procedures used to fabricate two of these types. The procedures are quite close and, with slight modifications, can be used for all termination types. You will carry with you an understanding of what a termination does and how to make them.

Around every power cable there are lines of magnetic flux. When a cable is whole (by whole I mean completely intact, no layers of the cable are missing) these lines of flux are present and do not cause many harms, because the natural makeup of the cable contains them. When you remove certain layers (the concentric neutral and the semi-conductive) these lines of flux expand and contract around this area. To dissipate these lines of flux and reduce the chance of cable failure we must terminate the cable in a prescribed manor. A termination provides this means by giving us a smooth transition between the cable and line equipment and dissipating the corona effect. A termination is effectively a choke point for these lines of flux.

There are many different types of prefabricated terminations: cold shrink, heat shrink, molded rubber, and porcelain, are a few. For the purposes of this lesson we will discuss the cold shrink type and the-do-it-yourself tape termination. The cold shrink type is widely used, while the tape termination is a good procedure that may come in handy one day when your out in the middle of nowhere with little to no supplies and have to fix a termination.

***To perform this task, follow these steps*:**

**Tape Terminations.**

Follow the cable manufacture's spec sheet.

**Step 1: Prepare cable.**

- Install the cable into the duct and train into place.

**NOTE:**
When cutting the cable leave one to two feet extra, this will allow for extra concentric neutral wire to bond to ground.

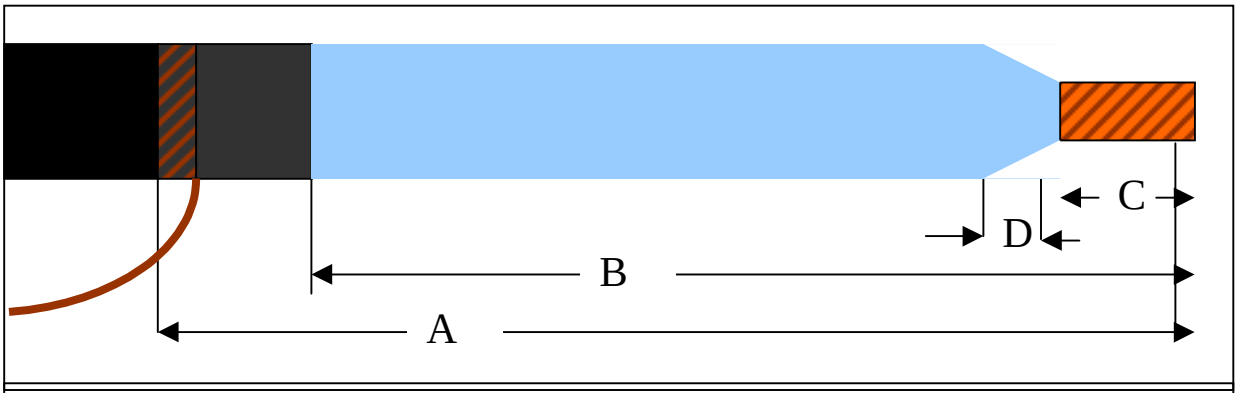
- Line the cable up with the connector on the transformer or other line equipment and mark the jacket, this is your point of reference for the start of the termination.
- Measure fourteen inches down the cable and mark. This is the point that you will remove the outer jacket.
- Remove the outer jacket down to second mark.

**SAFETY:**
**CARE SHOULD BE TAKEN NOT TO DAMAGE THE CONCENTRIC NEUTRAL WHILE REMOVING THE OUTER JACKET.**

- Peal the concentric, bundle it out of the way, and tape in place.
- Measure fourteen inches up from the outer jacket and cut the cable end off.
- Measure up from the outer jacket four inches mark the semi-conductive layer and remove.

**SAFETY:**
**WHEN REMOVING THE SEMI-CONDUCTIVE LAYER CARE SHOULD BE TAKEN NOT TO NICK THE INSULATION LAYER.**

- Clean and sand the insulation layer if needed.
- If using a commercially available termination connector (lollipop) measure the connector length. This will be the amount of insulation to be removed.
- Remove enough insulation to connect the cable to the line equipment or to connect the lollipop.
- Remove the semi-conductive material from the conductor.
- Pencil the insulation for ½ of an inch. When finished the cable should look like that in Figure 1.




| | | |
|---|---|---|
| A=14 inches | B= 10 inches | C= ½ the connector length or total length of conductor needed to make connection |
| D= ½ pencil | | |

**Figure 1, Prepared cable**

**Step 2: Applying Tape.**

- Start taping, with #130 high voltage rubber tape, two inches above the semi-conductive layer on the insulation of the cable using a highly elongated half lapped layering technique, this will be the middle of the stress-cone. Build the stress-cone in a back and fourth taping action until you have built a cone that is four inches long and just touches the semi-conductive layer (Figure 2).

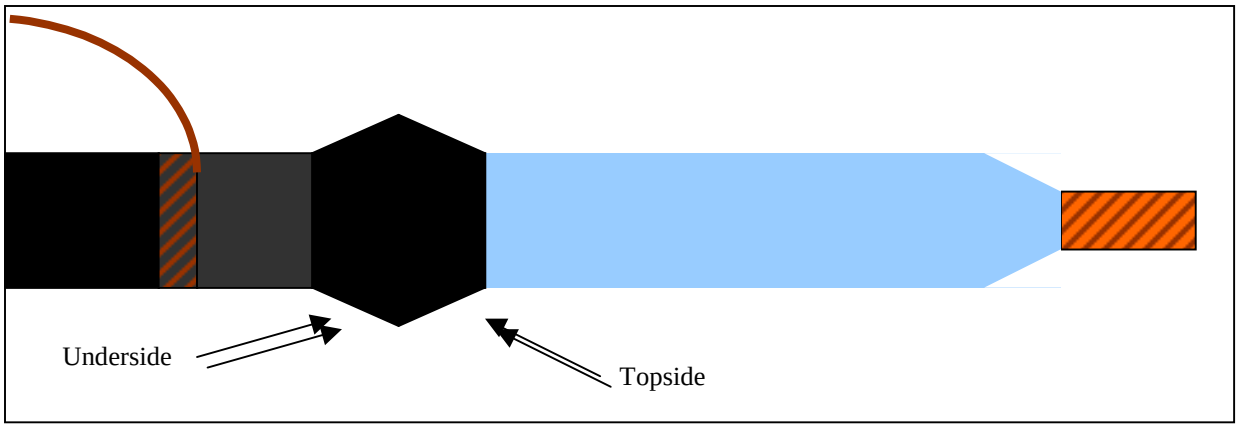



**Figure 2, Cable with Stress-Cone**

- When the stress-cone is finished apply two layers of semi-conductive #13 tape. Start at the concentric neutral, half lap the layers to the under side of the stress-cone and return to the concentric neutral (Figure 3).

**SAFETY:**
**DO NOT PUT SEMI-CONDUCTIVE TAPE ON THE TOPSIDE OF THE STRESS-CONE. THIS WILL MAKE THE STRESS-CONE CONDUCTIVE.**

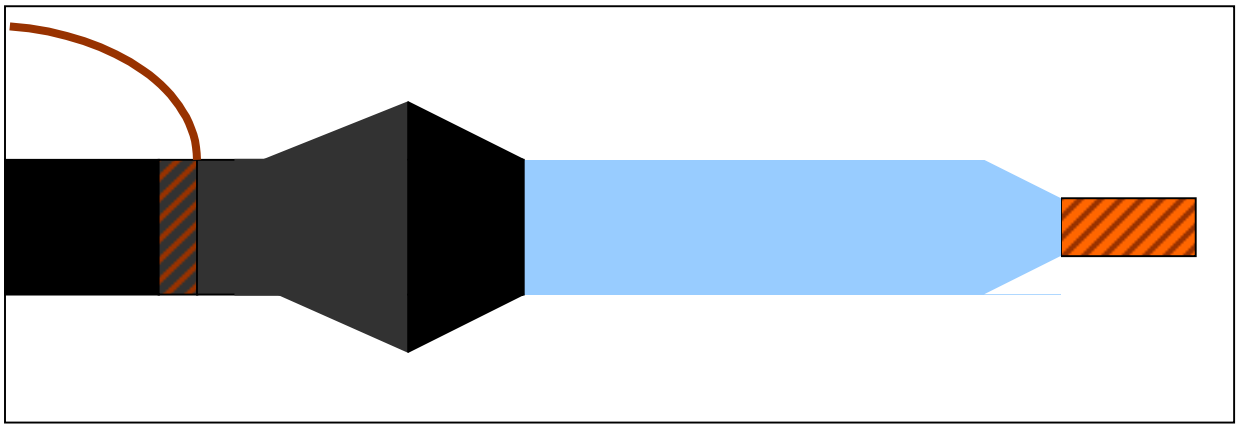


**Figure 3, Stress Cone with Semi-Con on Bottom**

- Next apply two layers of #33 (stick to just one example) vinyl electric tape, start at the concentric neutral and apply two layers of tape to the top of the stress-cone and on the insulation layer for ¼ of an inch. As seen in Figure 4.

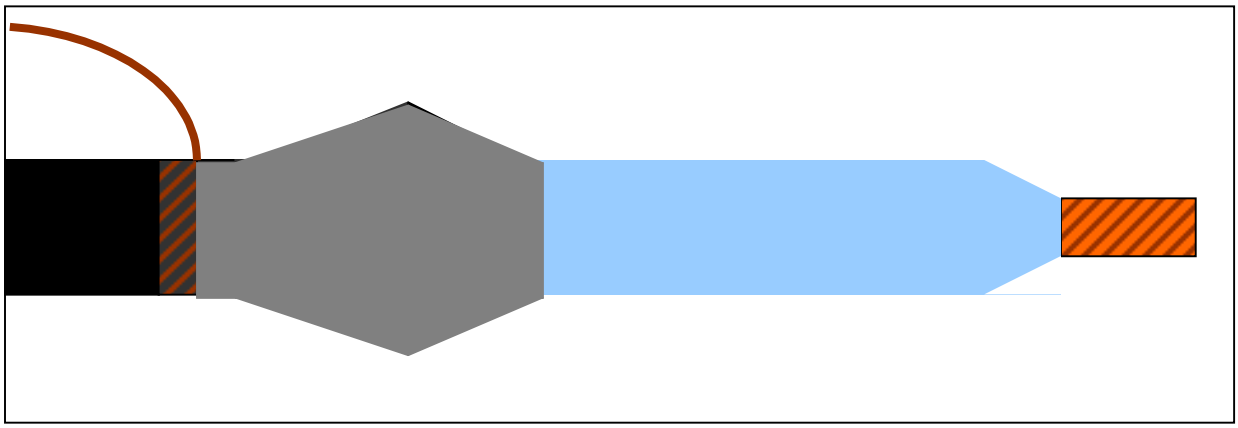


**Figure 4, Stress-Cone with Two Layers of Vinyl Tape**

- Twist all the strands of the concentric neutral together forming one conductor.
- As an added measure of moisture protection put two to three layers of vinyl tape on the termination starting just below the concentric neutral on the cable jacket up to the previously applied layer of vinyl tape.
- Slip on lollipop connector if used and crimp in place. Cut to length and connect to the line equipment (Figure 5).

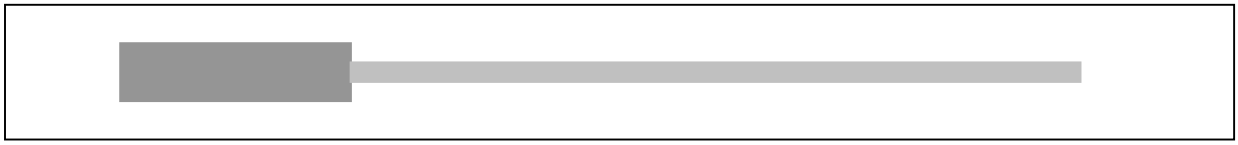


**Figure 5, Cable Termination Connector (Lollipop Connector)**

- Prepare and terminate other cables as needed.
- Bond the cable concentric neutrals together and to an appropriate ground.

**3M Cold Shrink Termination Kit.**

- These are only guidelines and the manufacturer specification sheet should be used to fabricate the termination.
- Install the cable into the duct and train into place.

**NOTE:**
When cutting the cable leave one to two feet extra, this will allow for extra concentric neutral wire to bond to ground.

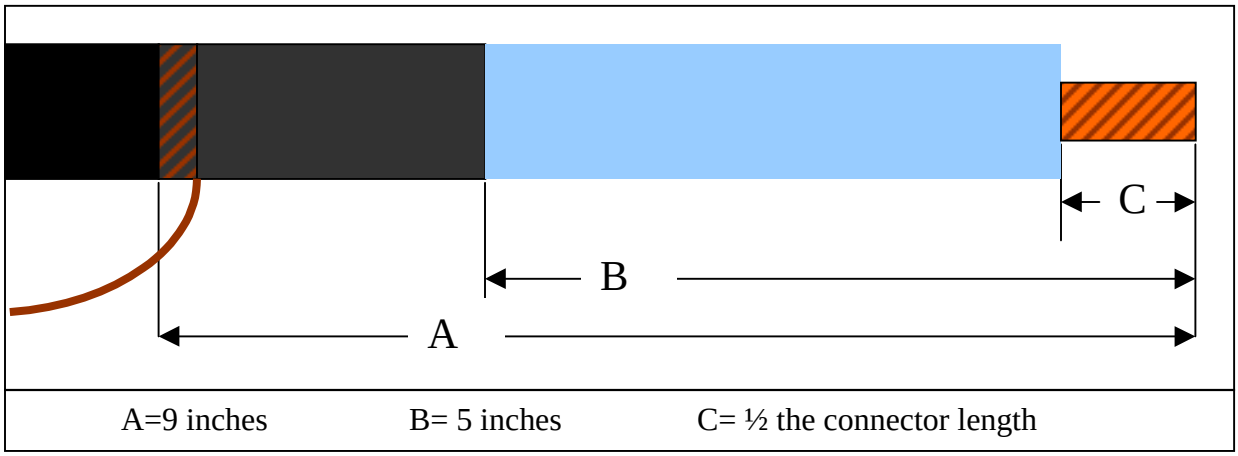
- Line the cable up with the connector on the transformer or other line equipment and mark the jacket, this is your point of reference for the start of the termination.
- Measure nine inches down the cable and mark. This is the point that you will remove the outer jacket.
- Remove the outer jacket from the end back to second mark.

**SAFETY:**
**CARE SHOULD BE TAKEN NOT TO DAMAGE THE CONCENTRIC NEUTRAL WHILE REMOVING THE OUTER JACKET.**

- Peal the concentric, bundle it out of the way, and tape in place.
- Measure nine inches up from the outer jacket and cut the cable end off.
- Measure down from end of the cable five inches, mark the semi-conductive layer and remove.

**SAFETY:**
**WHEN REMOVING THE SEMI-CONDUCTIVE LAYER CARE SHOULD BE TAKEN NOT TO NICK THE INSULATION LAYER**.

- Clean and sand the insulation layer if needed.
- Measure the connector length. This will be the amount of insulation to be removed.
- Remove the insulation.
- Remove the semi-conductive material from the conductor (Figure 6).




A=9 inches B= 5 inches C= ½ the connector length

**Figure 6, Prepared Cable**

- Put the connector on and crimp into place.
- Apply the silicone grease where the semi-con stops on insulation layer.
- Place the cold shrink tubing over the cable down to the concentric neutral. While holding it in place pull the pull string to allow the tube to shrink around the cable.
- Apply the rubber tape, that comes with the kit, to the end of the termination where the shrink sleeve and the connector come in contact, this is the weather seal.
- Place the C clamp around base of the termination and run two drip wires through the open ends. Then twist together tightly and blend into the other concentric neutral wires forming a tight bundle (Figure 7).
- Prepare and terminate the rest of the cables as needed.
- Bond and ground the terminations.

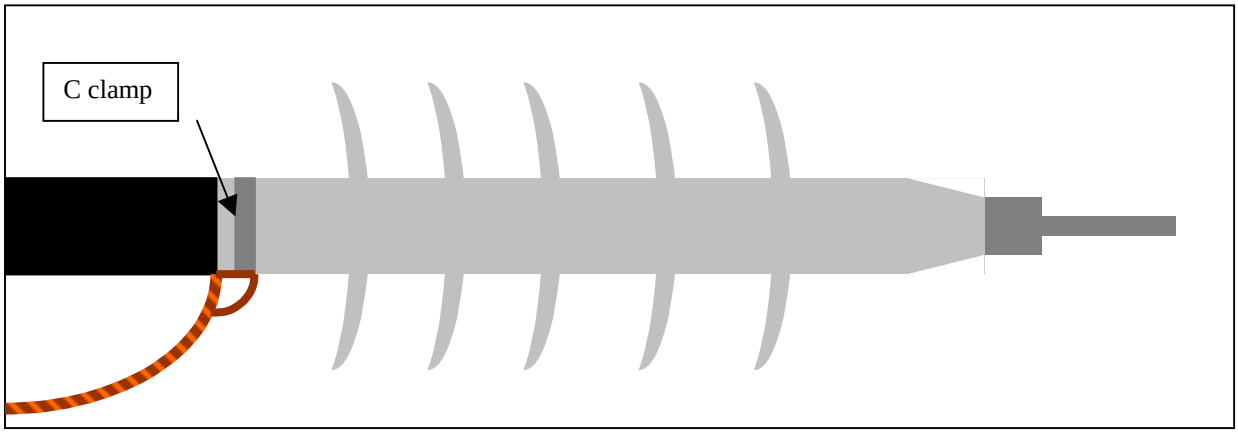



**Figure 7, Completed Termination with C Clamp in Place**

# Review Questions
# For
# Terminate High Voltage Underground Cables

| Question | Answer |
|---|---|
| 1. A termination is a/an _____ between the cable and the line equipment. | a. End point<br>b. Dead end<br>c. Transition<br>d. Connection |
| 2. Terminations are _____ for _____. | a. Easy for lineman.<br>b. Choke points for power.<br>c. Magnifiers for the lines of flux.<br>d. Choke points for the lines of flux. |
| 3. When terminating cable about how many feet extra is left to do the termination? | a. 1<br>b. 2<br>c. 3<br>d. 4 |
| 4. For a tape termination after setting the reference mark how many inches do you measure down the cable to remove the outer jacket? | a. 8<br>b. 10<br>c. 12<br>d. 14 |
| 5. For a tape termination which tape is used to form the stress-cone? | a. #130<br>b. #88<br>c. #77<br>d. #33 |
| 6. If the insulation is nicked you should _____ it. | a. Sand and clean<br>b. Do nothing to<br>c. Sand<br>d. Start over with |
| 7. In the cold shrink type termination what is used to bond the termination to ground? | a. A “C-type” clamp<br>b. The concentric neutral<br>c. Both A and B<br>d. Neither A or B |
| 8. What is done to the concentric neutral to add an extra measure of moister protection? | a. It is bent down.<br>b. It is covered with tape.<br>c. It is covered with silicone grease.<br>d. It is bundled out of the way. |

**TERMINATE HIGH VOLTAGE UNDERGROUND CABLES**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Can the trainee describe the need for a termination on high voltage cable | | |
| 2. Was spec sheet used and followed? | | |
| 3. Was the cable properly measured prior to cutting? | | |
| 4. Were the procedures followed while building the stress-cone for the tape termination? | | |
| 5. Was #13 semi-conductive tape only applied to the lower half of the stress-cone? | | |
| 6. Was the cable penciled if connecting directly to the line equipment? | | |
| 7. Was the specification sheet used to make the termination? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and the trainer.


# UNDERGROUND DISTRIBUTION SYSTEMS

## MODULE 17 AFQTP UNIT 6

## ELECTRICALLY TEST UNDERGROUND CABLE (17.6.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

# ELECTRICALLY TEST UNDERGROUND CABLES
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | • 17.6. Underground distribution systems, electrically test underground cables |
| **Training References:** | • CDC 3E051, B VOL3<br>• Lineman's and Cableman's Handbook<br>• AFI 32-1064 Electrical Safe Practices<br>• National Electric Safety Code(NESC)<br>• National Electric Code(NEC)<br>• Manufacture's specification sheet |
| **Prerequisites:** | • Possess, as a minimum a, 3E031 AFSC |
| **Equipment/Tools Required:** | • Grounding Set<br>• Personal Protective Equipment<br>• Rubber Protective Equipment<br>• Test set<br>• Hand Tools |
| **Learning Objective:** | • Given equipment, properly test underground distribution cables |
| **Samples of Behavior:** | • Following approved methods, properly use test set<br>• Know the safety requirements for properly testing underground distribution cables |
| **Notes:** | |
| • Any safety violation is an automatic failure<br>• Trainer will brief trainee on the components of the particular transformer to be grounded as well as describe operation of the grounding set used | |

**Background:** The reasons for testing underground cables are many and can range from doing the installation acceptance test to testing the integrity of a cable after splicing. In either case or extreme you are simply applying voltage to the cable to ensure that it can hold the source voltage normally applied. In this section we will show two methods of testing cables the high potential test set (hy-pot) and high voltage fault locator (thumper). The hy-pot test is used to check the integrity of the cable's construction. It will determine if the cable will handle the system voltage and help detect deteriorating cables. The thumper will assist you in locating a cable fault.
***To perform the task, follow these steps:***

**HY-POT TEST METHOD**

**Step 1: Isolate the cable.**

- Isolate the cables to be tested from all power sources and lock and tag-out the switches. Prior to doing any work on under ground cables that must be isolated and grounded for your safety.

**SAFETY:**
**DO NOT WORK ON ANY CABLES UNTIL THEY HAVE BEEN GROUNDED. CABLES CAN STORE A CHARGE, JUST LIKE A CAPACITOR, THAT CAN BE AS MUCH AS THE LINE VOLTAGE.**

**Step 2: Disconnect the cables.**

- Once the cable has been isolated remove both ends from the equipment it is connected to. This is done to keep from reading the leakage of any line equipment.

**SAFETY:**
**WHEN DISCONNECTING THE CABLES CARE SHOULD BE TAKEN NOT TO DAMAGE THEM IN ANY WAY.**

**Step 3: Install Warning Barricades.**

Using large traffic cones or traffic barricades with flagging tape. Erect a safety zone around the area that you are going to be working with the Hy-pot. The other end of the cable should also be coned off. Signs saying **DANGER HIGH VOLTAGE** should also be used. Allow only authorized personnel into these safety zones. Your safety zone should be at least 25 feet from any current carrying device and may be larger if space is available.

- Vehicles may also be inside this area however they should not inhibit your movement in the safety zone or create an unsafe condition (Figure 1).

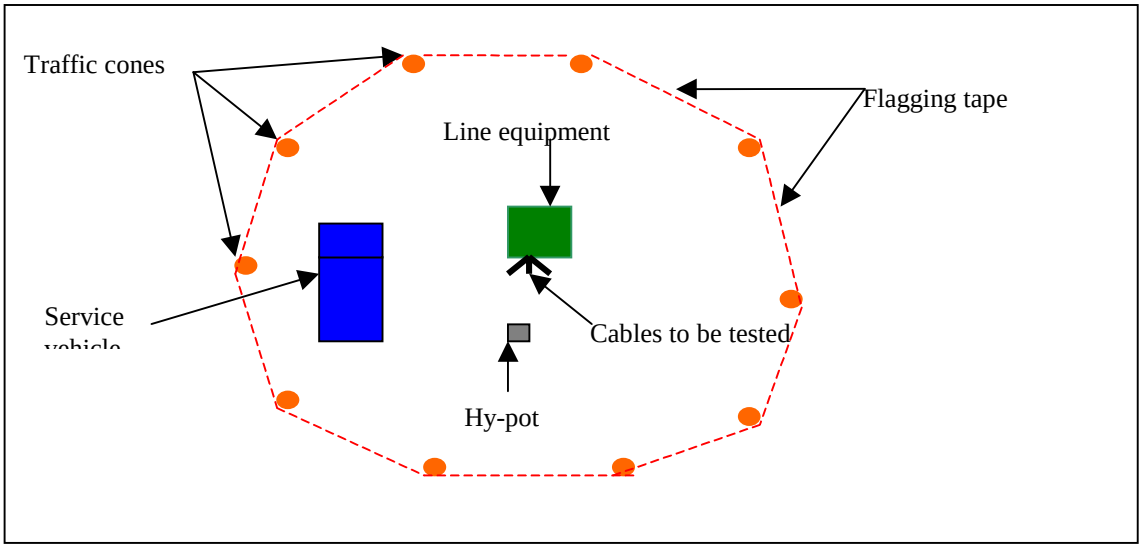



**Figure 1. Typical Safety Zone.**

**NOTE:** If space is not available to give the 25 foot safety zone use what is available. Curious bystanders should be protected from their own curiosity.

**Step 4: Isolate test end of cable.**

Wrap the top of a barricade or other suitable device in a rubber blanket and place the cables to be tested on it. This will give you a solid surface to secure the cables during the testing. If the cables are not long enough to setup out side the piece of equipment you should use rubber blankets to isolate the cables from the case and the connections.

**Step 5: Isolate non-testing end of cables.**

Use a barricade or other suitable device covered with a rubber blanket to set the cables on during testing, this will keep from giving a false reading. A blanket may also be placed around the cables being tested as an added measure of safety.

**Step 6: Connect the Hy-pot.**

Connect the Hy-pot to the cable to be tested as per manufacture's specifications. The high voltage connection should be as tight as possible and should also be wrapped with a bag to cut down the chance of damaging the cable from corona discharge and to eliminate faulty readings due to corona.

**Step 7: Test the cables**

Use the Hy-pot in accordance with the manufactures' specifications. Test the first cable. Test the remaining cables as described above.

.

**SAFETY: AFTER EACH CABLE HAS BEEN TESTED LET IT SIT FOR FIFTEEN MINUTES THEN GROUND IT TO DISCHARGE ANY STRAY VOLTAGE STILL ON THE CABLE**

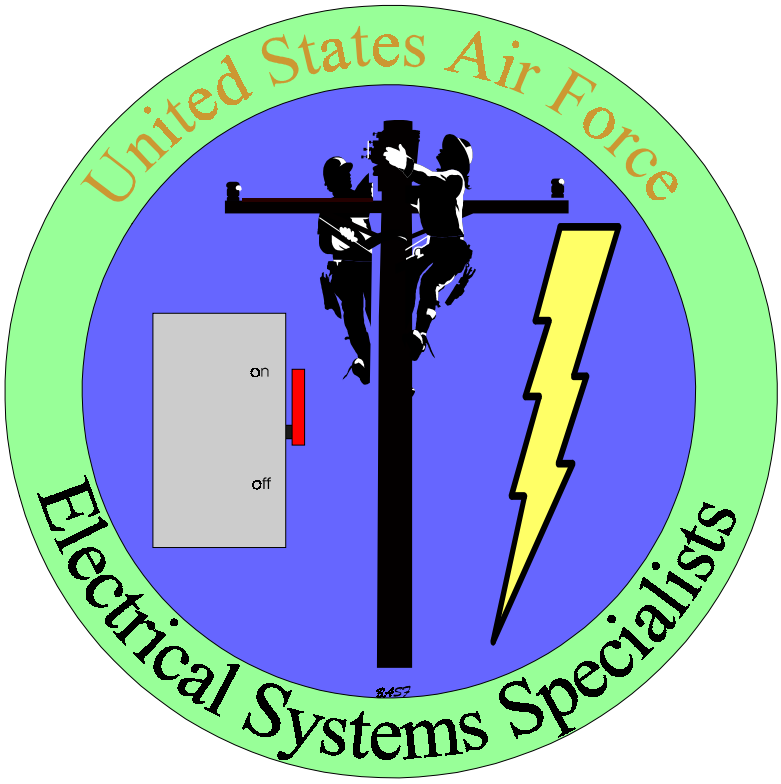
# Review Questions
# For
# Electrically Test Underground Cable

| Question | Answers |
|---|---|
| 1. Your safety zone should be at least _____ from any current carring device. | a. 2 feet<br>b. 10,560 feet (Bad distracters)<br>c. 25 feet<br>d. 3.2 kilometers |
| 2. Prior to working on underground cables they must be _____ and _____? | a. Isolated and Grounded<br>b. Cleaned and Lubricated<br>c. Disconnected and Reconnected<br>d. Cleaned and Grounded |
| 3. After Isolating cables _____ and _____the switches. | a. Clean , Lubricate<br>b. Lock, Tag-out<br>c. Secure, ground<br>d. Reconnect, re-energize |
| 4. Vehicles are not allowed inside of the safety zone. | a. True<br>b. False |
| 5. How do you prevent from getting false readings? | a. Test cable while energized.<br>b. Test cable while de-energized.<br>c. Test cable while still connected.<br>d. Isolate both ends of cable to be tested. |

**ELECTRICALLY TEST UNDERGROUND CABLE**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Were warning barricades placed creating a safety work zone? | | |
| 2. Was the cable properly isolated and grounded prior to testing? | | |
| 3. Was the Hy-pot connected as per manufacturer instructions? | | |
| 4. Did the trainee use the Hy-pot as per manufacturer instructions? | | |
| 5. Did the trainee allow the cable to sit for 15 minutes before discharging it to ground? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and the trainer.




# UNDERGROUND DISTRIBUTION SYSTEMS

**MODULE 17** **AFQTP UNIT 7**

## TROUBLESHOOT UNDERGROUND SYSTEM CABLES FOR FAULTS (17.7.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

# TROUBLESHOOT UNDERGROUND SYSTEM CABLES FOR FAULTS
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | • 17.7. – Underground distribution systems, troubleshoot underground system cables for faults |
| **Training References:** | • CDC 3E051B VOL3<br>• Lineman's and Cableman's Handbook<br>• AFI 32-1064 Electrical Safe Practices<br>• National Electric Safety Code(NESC)<br>• National Electric Code(NEC) |
| **Prerequisites:** | • Possess, as a minimum a, 3E031 AFSC |
| **Equipment/Tools Required:** | • Grounding Set<br>• Personal Protective Equipment<br>• Rubber Protective Equipment<br>• Test sets<br>• Hand Tools |
| **Learning Objective:** | • Given equipment, troubleshoot underground cable systems for faults |
| **Samples of Behavior:** | • Following approved methods, troubleshoot underground cable systems for opens, shorts and grounds<br>• Know the safety requirements for troubleshooting underground cable systems |
| **Notes:** | |
| • Any safety violation is an automatic failure<br>• Trainer will brief trainee on the components of the particular transformer to be grounded as well as describe operation of the grounding set used | |

## TROUBLESHOOT UNDERGROUND SYSTEM CABLES

**Background:** To find a fault in a cable whether it is in a duct or a direct buried cable, a megohmmeter (commonly referred to as a megger) is used in conjunction with a cable tracer/fault locator. You may have seen a megger before when conducting checks for transformer opens, shorts, and grounds. Remember—a reading of zero (0) means there is no resistance or a short between the leads; Infinity (∞) indicates there is an infinite amount of resistance or an open between the megger leads. When troubleshooting underground cable, you might be testing several miles of cable at a time. Attaching the meter leads to each end of the cable, as you did to measure continuity of transformer windings, would be impossible. Therefore, you need a set of jumper leads which will be used to short the cables at the far end so megger readings can be taken without having meter leads several miles long. A fault in a cable means it is defective. There are three basic kinds of cable faults: opens, shorts, and grounds. Each type has its own characteristic that can be detected by using a megger. However, regardless of the type of fault, your system is out of service until the cable can be repaired.

An open, for instance, in a conductor simply means there is a break in the conductor. There can be no current flow through the open. Opens rarely occur by themselves in high voltage cables. If a high voltage cable is cut, the resulting fire usually causes the cable to ground out and possibly burn other cables near it. A short, on the other hand, in a circuit results when two or more conductors touch, or a conductive material goes across two or more conductors. The conductive material in high voltage cables is usually water. The insulation weakens and current flows through the insulation between the conductors. Grounded conductors, however is a situation in which one or more conductors have made an electrical contact with a ground. The result is current flow through ground back to the source. When a high voltage cable is grounded the insulation has gone bad. The current flows through the insulation and causes over-current condition.

***To perform the task, follow these steps:***

**Step 1: Isolate Cables.**

- Before you attempt to troubleshoot an underground system, you must isolate it from any source of voltage. To do this, you must initiate and follow all safe clearance procedures.

**SAFETY:**
**NEVER ATTEMPT TO TROUBLESHOOT A CABLE THAT HAS NOT BEEN PROPERLY ISOLATED. CONTACTING AN ENERGIZED CABLE CAN BE EXTREMELY HAZARDOUS.**

**Step 2: CHECK FOR VOLTAGE.**

- Using an appropriate meter verify that the cable has been isolated from all possible voltage sources.

**Note:**
Prior to checking the isolated cables for voltage you need the verify that the meter you using is working properly, by checking a known live circuit with the meter both before and after you test the isolated cables.

**Step 3: GROUND CABLES.**

- Ground the cables to bleed off any residual voltage (static charge) still on the line.

**Step 4: DISCONNECT CABLES.**

- After the system has been rendered safe to work on, you may begin disconnecting the cables from all line equipment, such as transformers, regulators, capacitors, etc. The objective is to test the cable—not the equipment—so everything must be disconnected.

**Step 5: CHECK MEGGER**

- Verify that the megger is working correctly by connecting its' leads together and pushing the test button or turning the crank handle. The meter reading should read 0. Next separate the test leads, push the test button or turning the crank handle, the meter reading should be ∞.

**NOTE:** Always ensure that you are familiar with and know how to use your equipment prior to performing any test. Meters may look the same but operate differently. For instance, the small battery operated Biddle Megger, depending on which voltage scale it is set to, meter will deflect different directions. If you are not aware of this you might think you have bad cable when actually it is operator error.

**Step 6: CONNECT MEGGER.**

- The type of fault you suspect will determine the way in which the meter is connected to the cables. However, when a cable is suspected of being faulty, it will be tested for all three types of faults: opens, shorts, and grounds.

**Opens.** To determine the continuity of the conductors, you must first short the conductors at the far end and then test between conductor pairs. If the conductors are continuous, you will read zero ohms.

**Shorts.** A megger is used to check for a short circuit between conductors. Make the test between possible combinations of cables (example: a-b, a-c, b-c). If you get a reading other than infinity on the megger, a short circuit is indicated. If the megger reading is ∞ (infinity), the conductors are NOT shorted together.

**Grounds.** When you check for a grounded conductor, using a megger, test between each conductor and ground while the far end of the cable is open. If you obtain a reading other than ∞ (infinity) on the megger, a ground is indicated.

**STEP 7: TEST CABLES**

**SAFETY:**

**PRIOR TO TURNING THE HAND CRANK OR PUSHING THE TEST BUTTON, ENSURE THAT THE CONNECTIONS ARE TIGHT AND ALL PERSONNEL ARE CLEAR OF THE CABLES**

- Test the cables in the manor described above for each of the cable faults. If anything but good cable is found, you have just begun your day. New cable will have to be pulled or the fault located and repaired.

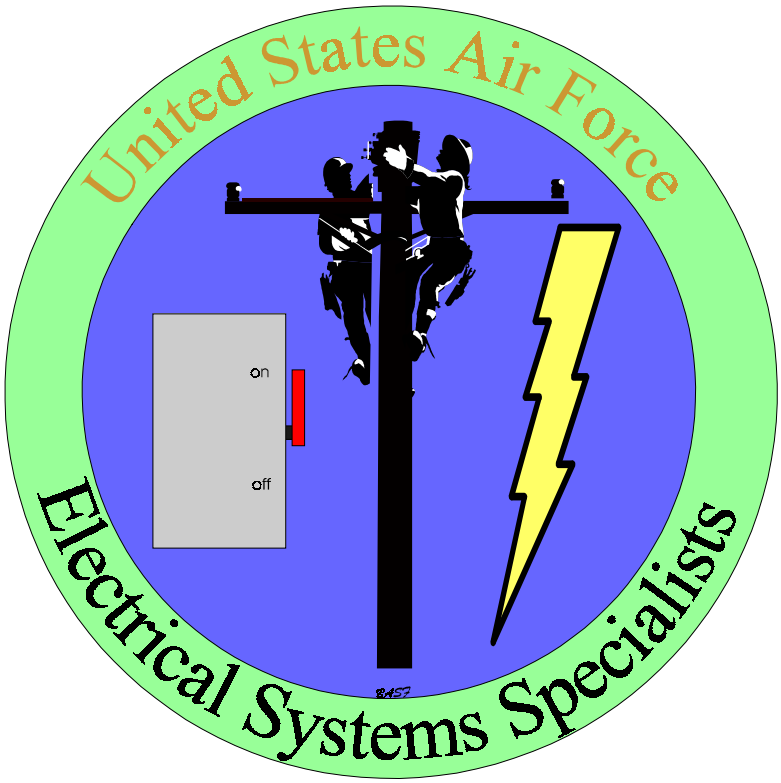
# Review Questions
# For
# Troubleshoot Underground Cable

| Question | Answers |
|---|---|
| 1. Before you attempt to troubleshoot an underground system, you must _____. | a. Obtain an AF Form 103.<br>b. Isolate it from any source of power<br>c. Check for ground clearance.<br>d. Connect to a power source. |
| 2. To find a fault in a cable, a _____is used. | a. Ohmmeter<br>b. Multimeter<br>c. Megohmmeter<br>d. Ammeter |
| 3. Three types of fault cables are tested for are? | a. Opens, shorts and grounds<br>b. Grounds, cross currents, and opens<br>c. Opens, closed and shorts<br>d. None of the Above |
| 4. Which meter is preferred when checking for opens? | a. Ohmmeter<br>b. Multimeter<br>c. Megohmmeter<br>d. Ammeter |

**TROUBLESHOOT UNDERGROUND CABLE**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Did the trainee isolate the cable before troubleshooting? | | |
| 2. Did the trainee correctly use the megohmmeter to check cable? | | |
| 3. Can the trainee explain the three types of faults? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and the trainer.




# UNDERGROUND DISTRIBUTION SYSTEMS

**MODULE 17** **AFQTP UNIT 8**

## TRACE UNDERGROUND CABLE WITH CABLE TEST SET (17.8.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

# TRACE UNDERGROUND CABLE WITH CABLE TEST SET
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | 17.8. – Underground distribution systems, trace underground cables with cable test set |
| **Training References:** | • Manufacturer's operating instructions |
| **Prerequisites:** | • Possess as a minimum a, 3E031 AFSC. |
| **Equipment/Tools Required:** | • Underground cable test set<br>• Cable |
| **Learning Objective:** | • Given equipment, locate underground cable |
| **Samples of Behavior:** | • Follow required steps while locating underground cable using a cable test set<br>• Know safety requirements to locate underground cable |
| **Notes:** | |
| • Any safety violation is an automatic failure. | |

## TRACE UNDERGROUND CABLE WITH CABLE TEST SET

**Background:** There are many reasons we must be able to trace cable locations, the most common being, clearing an area for digging. Although maps will give a general location and route, we must be able to locate a buried line with-in a few feet. How well you can locate cable could mean the difference between a smooth job and a major power outage with lots of overtime. Another reason to trace cables would be to locate a fault. With a quick visual check we can find faults or flaws in exposed conductor joints or equipment. Driving over the conductor route may enable you to locate faults. While driving the conductor route, you might spot things that imply possible conductor failure. Things such as displaced manhole covers, smoke coming from a manhole, places where digging has taken place, melted snow, and burnt grass or holes dug by rodents are usually good indications. Sometimes a burnt smell will reveal a fault has recently happened. If none of the above are apparent some type of conductor tracing and fault finding technique must be used.

***To perform the task, follow these steps:***

**Step 1: Check proper operation of line tracer.**

**NOTE:**
There are many types of cable test sets on the market. Most are similar in operation. We will discuss the METROTECH 810 cable locator. It consists of a transmitter (Figure 1), Receiver (Figure 2), and conductor attachment assembly. Refer to the manufacturer's operating instructions if you have a different model.


**Figure 1, Transmitter Controls and Indicators**

**Figure 2, Receiver**

- Pull the 810-power switch on.
- Push the power test button. The power test lamp will light if there is adequate battery power for operation of the 810.
- Fully extend the Receiver antenna: (Loosen the nut on the stem assembly and extend the stem as far as possible. Tighten the nut to secure the stem.)
- Set the Receiver functions switch to battery test (second position). The needle on the left/right guidance meter should be to the right of the line labeled battery test, as shown in Figure 3. The farther the needle is to the right of this line, the greater the charge in the batteries. If the needle is to the left of the line, the Receiver batteries should be replaced.

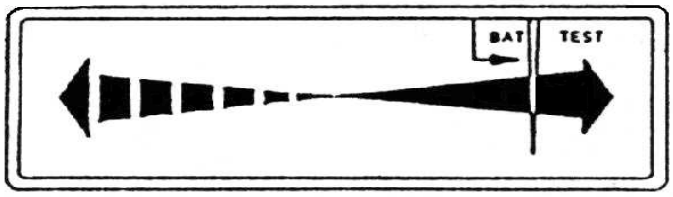



**Figure 3, Position of Meter Needle for Battery Test**

- Move the Receiver function switch to the tracing position (third position).
- Position the Receiver as shown in Figure 4. The end of the Receiver needs to be close to the transmitter, not more than 6 inches away. The digital signal strength indicator should display 950 or above. (Note the field strength figure; you will be using it for comparison in the next step of the procedure.)

- Position the Receiver selector switch in the line tracing mode (third position), move the Receiver back from the transmitter 2 to 5 feet. Point the Receiver at the transmitter as in Figure 4, the left/right guidance needle will be centered on the meter and the tone will be silent.

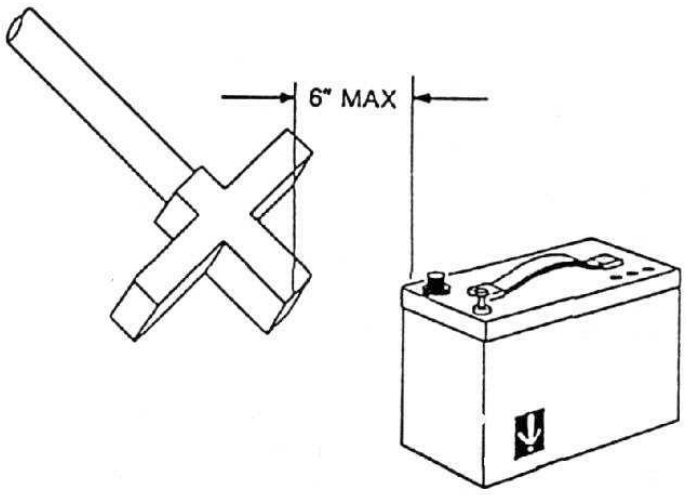



**Figure 4, Position of the receiver for checkout**

- Point the Receiver to the left and right of the transmitter centerline. The needle should follow the change in direction (solid arrow and continuous tone when you move right, broken arrow and broken tone when you move left) (Figure 5).

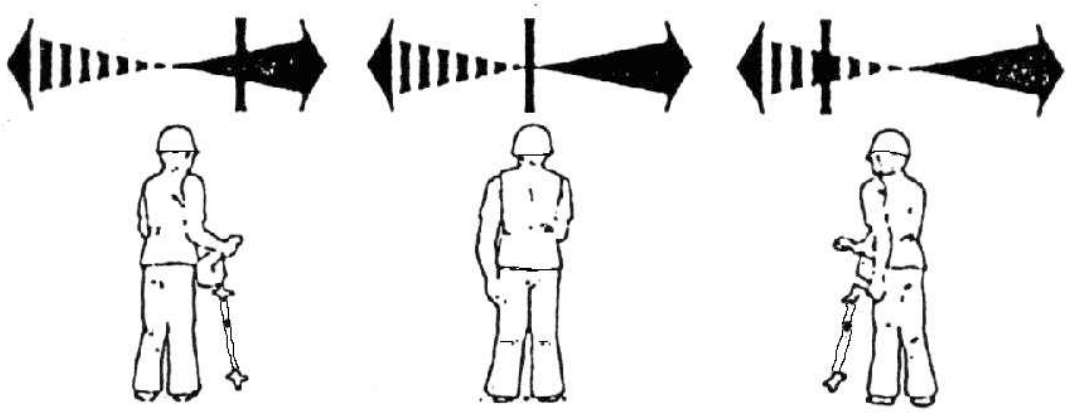


**Figure 5, Checkout Receiver Directional Meter**

- Center the needle on the meter.
- When the meter is centered, press and release the depth button. A depth reading should be displayed. Although the readout will not be accurate, it will indicate that the depth capability is functioning.
- Turn the transmitter off by pushing the power switch down.

**Step 2: Test the conductive attachment for loose or broken wires.**

- Connect the black and red ends of the conductor attachment together. Lay the connected wires out on the floor in a circular configuration (Figure 6). Plug the conductor attachment into the direct/4820 clamp jack of the transmitter.
- Turn the transmitter on by pulling the power switch up.
- With the Receiver not extended, place the tip directly on one of the conductive wires.
- Turn the selector switch on the Receiver to the fourth position (field strength only). The field strength should be at the same or very close to the reading in "test procedure steps 5 and 6 above". The reading should be constant and not fluctuate.
- While watching the field strength readout, wiggle each connection point on the conductor attachment at the direct 4280 jack and at the clamp end of each of the conductor attachment wires (red and black). The field strength should not change; any fluctuation in the reading indicates a loose or broken wire within the conductor attachment.
- Turn the transmitter off.

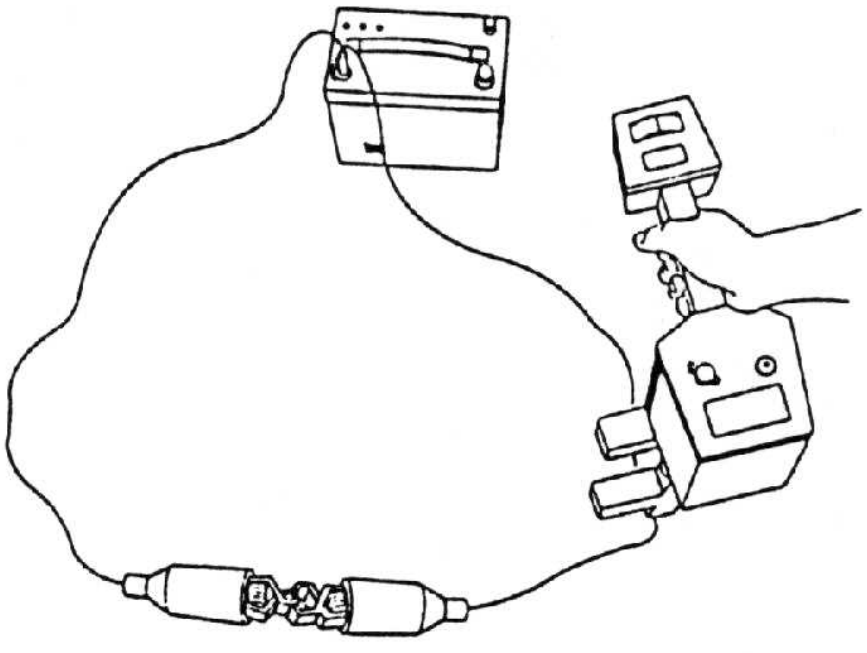


**Figure 6, Configuration for Testing the Conductor Attachment**

**SAFETY:**
**DO NOT CONNECT THE TRANSMITTER DIRECTLY TO A LIVE POWER CONDUCTOR. ALWAYS MAKE SURE THE POWER TO A CONDUCTOR IS TURNED OFF, LOCKED, TAGGED-OUT, AND GROUNDED BEFORE YOU CONNECT THE TRANSMITTER TO IT.**

**Step 3A: Proceed to locate the wire. Direct (Conductive) Connect.**

- With the transmitter off, plug in the direct connect cable into the jack labeled direct/4820 clamp on the 810 transmitter.
- Attach the red lead of the direct connect cable to an electrically clean metallic part of the targeted conductor.
- Move the transmitter away from the conductor in a right angle direction.
- Extend the black lead of the direct connect cable as far as possible from the transmitter, maintaining a right angle orientation. At this point drive the ground spike into the ground as far as possible, and attach the black lead to it. Use the ground plate only when the ground is too hard to drive in the spike. Place the plate on the ground (at right angles to the conductor) and attach the black lead (Figure 7). To improve the conductivity of the plate pour water under the plate and/or a weight on top of it.
- Turn the transmitter on by pulling the power switch on.
- Trace the signal with the 810 Receiver.

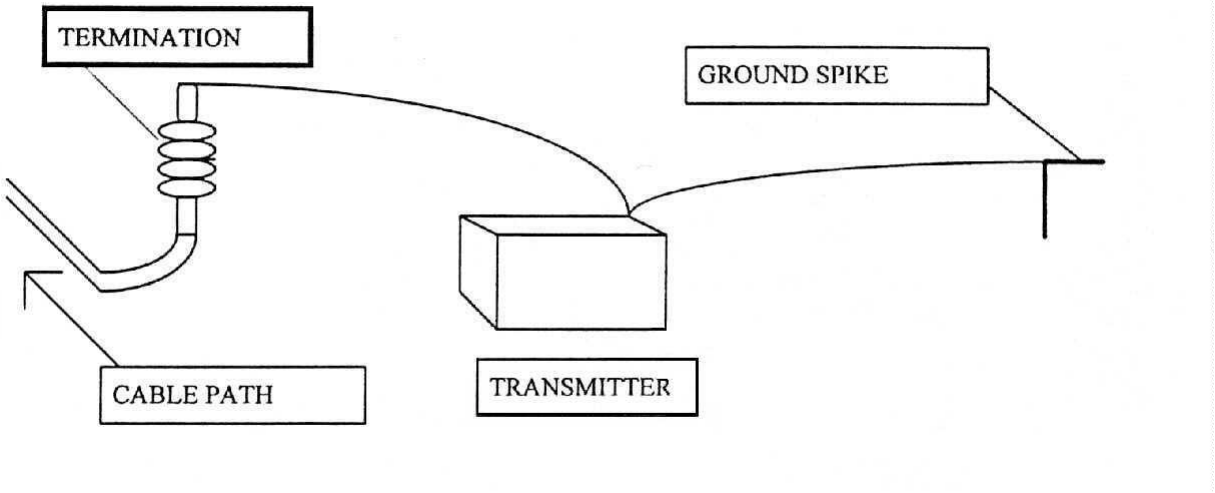



**Figure 7, Direct (Conductive) Connect**

**Step 3B: Inductive (Indirect Method)**

- Find a place over the target conductor that is at least 100 feet away from where you will he searching with the Receiver. If the transmitter is very close to the Receiver, more signals may reach the Receiver by air coupling than by coupling through the conductor. Position the transmitter over the buried cable, making sure the conductor direction arrow is parallel to the cable as seen in Figure 8.

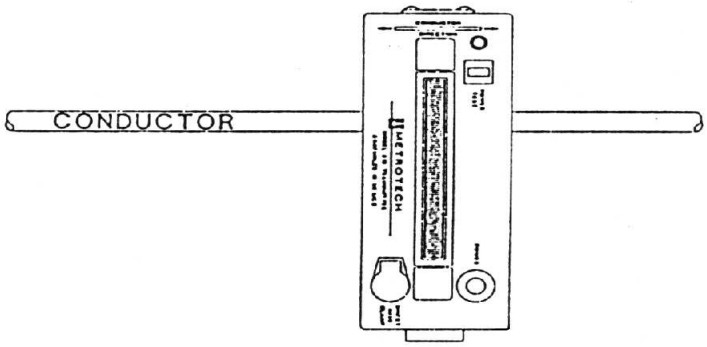



**Figure 8, Position for Inductive Coupling (Indirect Method)**

- Turn the transmitter on by pulling the power switch up.
- Trace the signal with the 810 Receiver described in the following section.

**Step 3C: Indirect (Inductive Coupling with the Metroclamp).**

**NOTE:**
When tracing lines that have insulators, the insulators must be bypassed, using the supplied jumper cables.

- With the transmitter off, plug the 4820 Metroclamp cable into the direct 4820 clamp jack.
- Place the Metroclamp around the conductor below the electrical ground as seen in Figure 9. Make sure that clamp jaws are fully closed.

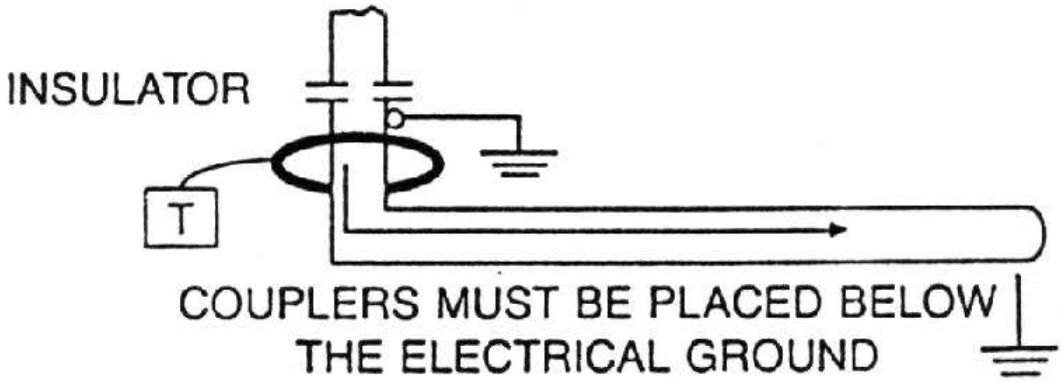



**Figure 9, Inductive Coupling with the Metroclamp.**

- Turn the transmitter on by pulling the power switch up.
- Trace the targeted conductor with the 810 Receiver.

**Step 4: Using the receiver.**

- Loosen the nut on the Receiver stem assembly and extend the stem as far as possible. Tighten the nut to secure the stem.
- Turn the Receiver power switch to "on" (third position).
- Go to the search area and sweep the area, moving the Receiver from side to side.
- The visual indicators and audio tone on the 8I0 Receiver will guide you toward the conductor. The needle on the left/right guidance meter will move to the right and the tone will be steady if the conductor is to your right. The needle will move to the left and the tone will pulse if the conductor is to your left. The signal (or field) strength on the digital display (LCD) will rise as you approach the conductor. As you close in on the location of the conductor, the meter will move towards the center, the signal strength on the LCD will get higher, and the tone will become silent. When the Receiver is directly over the conductor, the needle is in the center of the meter, the field strength is at its peak number, and the tone is silent (Figure 10).

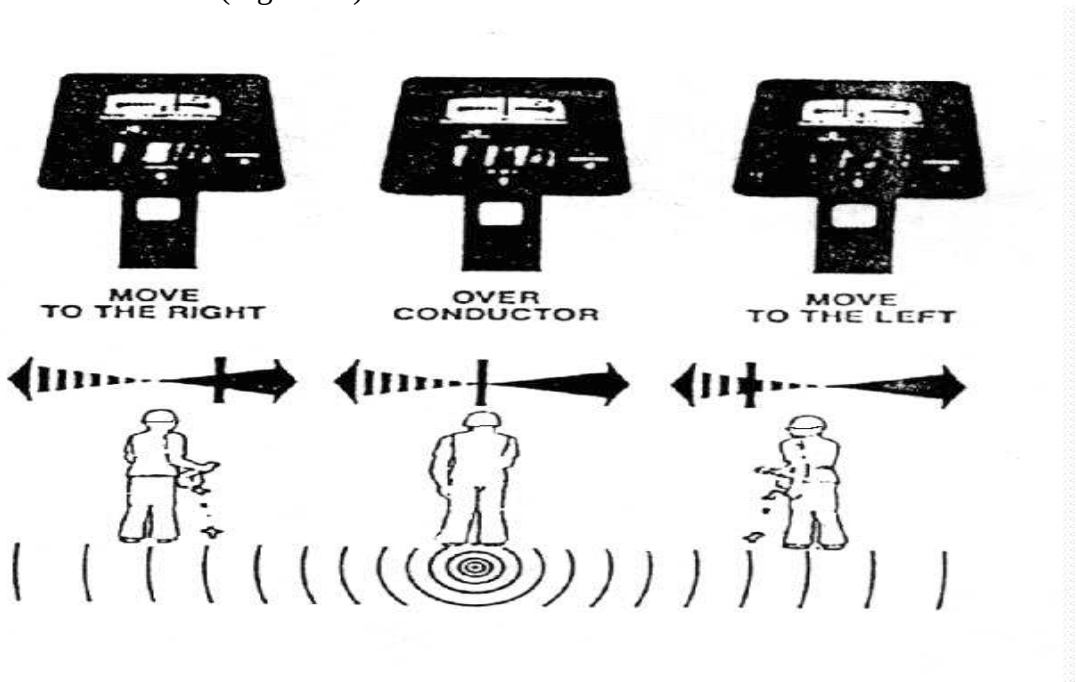



**Figure 10, Receiver Guidance System**

- To determine the direction of the conductor stop, vertically rotate the Receiver to the left and right. The highest signal strength reading indicates the conductor direction. Continue to trace the conductor in the direction indicated by the indicators on the Receiver. If the signal strength drops abruptly, the conductor may have changed direction or stopped.
- To verify the conductor's location. Press the depth button. A stable depth reading should appear on the LCD. If the display is blank, you are no longer over the conductor. If illogical or blinking numbers appear on the LCD, you may be over an interfering conductor, or a conductor that is beyond the depth range of the instrument (13 feet).
- When you pinpoint the conductor's location mark it by spray painting a line or placing a marking flag indicating the cable route..
- When you finish, turn the Receiver off, loosen the nut and retract the Receiver's stem. Turn the Transmitter off. Put all components back into the carrying case.

# Review Questions
# for
# Trace Underground Cable with Cable Test Set

| Question | Answer |
|---|---|
| 1. When doing a battery check on the Metrotech 810, the needle should be to the left of the battery test line. | a. True<br>b. False |
| 2. The digital signal strength indicator should display _____ or above when doing a functional check of the receiver? | a. 600<br>b. 650<br>c. 750<br>d. 950 |
| 3. How does the directional meter react when you move to the right of the transmitter centerline? | a. Solid arrow and continuous tone.<br>b. Broken arrow and broken tone.<br>c. Solid arrow and wavering tone.<br>d. None of the above. |
| 4. Any fluctuation in the meter reading during a conductive attachment test indicates _____. | a. A solid connection.<br>b. A loose or broken wire within the conductor attachment.<br>c. A low battery.<br>d. A short in the receiver. |
| 5. What is/are the name of the procedure(s) for locating underground cables? | a. Direct (conductive) connect.<br>b. Inductive (indirect method).<br>c. Indirect (inductive coupling with the metroclamp)<br>d. All of the above. |
| 6. Connect the black lead of the transmitter to the targeted conductor when doing a direct (conductive) test. | a. True.<br>b. False. |
| 7. How can conductivity be improved when using the ground plate? | a. Pour water on top of the plate.<br>b. Drive a ground rod.<br>c. Pour water under the plate.<br>d. Place ground plate closer to transmitter. |
| 8. Place the transmitter over the conductor at least ____ feet away from where you will be searching with the receiver. | a. 50<br>b. 100<br>c. 150<br>d. 200 |
| 9. When using the Indirect (inductive coupling with the Metroclamp) method, you must clamp below the electrical ground. | a. True<br>b. False |
| 10. When the receiver is directly above the conductor, what tone will you here? | a. Silence (no tone)<br>b. Steady tone<br>c. Pulsing tone<br>d. The tone will get louder when you are above the conductor. |

**TRACE UNDERGROUND CABLE WITH CABLE TEST SET**

| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Did the trainee check for proper operation of equipment prior to use? | | |
| 2. Did the trainee properly isolate circuit before tracing wire? | | |
| 3. Did the trainee connect the transmitter leads properly to target conductor? | | |
| 4. Did the trainee properly use the receiver? | | |
| 5. Did the trainee properly mark the circuit as it was traced? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.


# UNDERGROUND DISTRIBUTION SYSTEMS

## MODULE 17 AFQTP UNIT 10

## FABRICATE LOADBREAK ELBOW (17.10.)

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

# FABRICATE LOADBREAK ELBOW
## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | 17.10. – Underground distribution systems, fabricate loadbreak elbow |
| **Training References:** | • CDC 3E051 B Vol. 3<br>• T.O. 35CA2-2-10-1 Page 35 (Secondary Distribution Center)<br>• Manufacturer's specifications |
| **Prerequisites:** | • Possess as a minimum a, 3E031 AFSC. |
| **Equipment/Tools Required:** | • Loadbreak elbow<br>• Knife<br>• Ruler<br>• Crimper<br>• Lineman pliers<br>• Cable<br>• Needle nose pliers |
| **Learning Objective:** | • Given equipment, fabricate a loadbreak elbow |
| **Samples of Behavior:** | • Follow the required steps in fabricating a loadbreak elbow<br>• Know the safety requirements for fabricating a loadbreak elbow |
| **Notes:** | |
| • Any safety violation is an automatic failure. | |

## FABRICATE LOADBREAK ELBOW

**Background:** Because of the increasing need to test and isolate underground cable, a means of separating the cables quickly was developed. By the use of loadbreak elbows, you can separate lines with ease and connect them back together without fabricating time consuming terminations.

Elbow connectors provide a quick and reliable means of terminating cables. An elbow termination does not require the need for any special tools or equipment. It is one of the quickest and easiest methods of terminating high voltage underground cable. A cut away view of a typical Loadbreak elbow is illustrated in Figure 1.

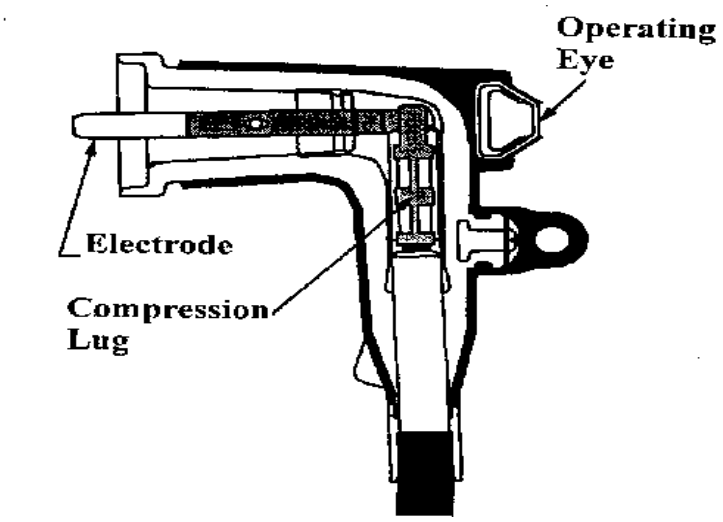



**Figure 1, Cut away of Loadbreak Elbow**

Loadbreak elbows have been designed to make isolating underground systems very easy. There are two types of elbows, Loadbreak elbow and a bolt-on elbow. The primary difference between the two is the ability for the Loadbreak elbow to be opened under a load bearing condition. A Loadbreak elbow contains a ceramic tip that will break the arc formed when the Loadbreak elbow is pulled from its bushing. Without this ceramic tip an elbow can not be opened under a load condition.

When using a Loadbreak elbow to isolate a circuit, make sure to use the proper equipment to remove the Loadbreak elbow from the bushing. A Grip-all hot stick (shotgun) can be used to remove an elbow, however this is not the preferred tool for the job. The ideal tool is an elbow puller tool. This tool is designed specifically for removing elbows from bushings. Whenever possible use this tool for removing elbows under a load condition.

***To perform the task, follow these steps:***

**Step 1: Train cable into position.**

- Straighten the natural curve of the cable allowing it to be properly set on the equipment's bushing once the elbow is completed.

A two-inch offset to provide adequate clearance for disconnecting elbows when placed on the parking stand (Figure 2).

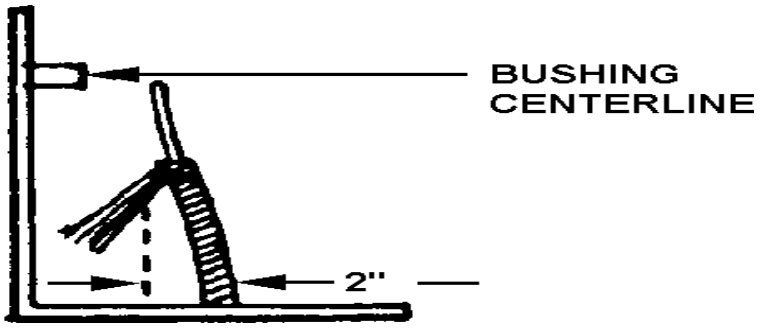



**Figure 2, Two-inch offset for clearance**

**NOTE:**
Be sure there is enough cable and concentric neutral length to allow for load break operation and parking of elbow. Be sure that the concentric neutral is long enough to reach ground connection

**Step 2: Prepare cable.**

- Included with most instructions for an elbow is a template for preparing the cable end.
- This template is a graphical representation of all of the dimensions necessary to properly remove the different layers of the cable.
- Unwind sufficient additional metallic shielding from cable prior to cutting the cable to make the ground connection.

**NOTE:**
Be certain to measure correctly before cutting the cable end, there is not any method of stretching cable to make it reach.

- Wrap a short length of scrap concentric wire, or electrical tape, around the cable 9” from the end this prevents the concentric neutral from becoming loose.
- Cut cable squarely at bushing centerline (Figure 3).

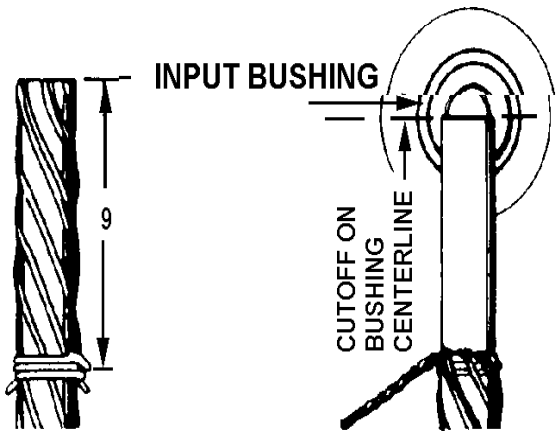



**Figure 3. Cutoff of Bushing Centerline**

- Remove 1–15/16” of insulation and jacket from conductor (Figure 4).

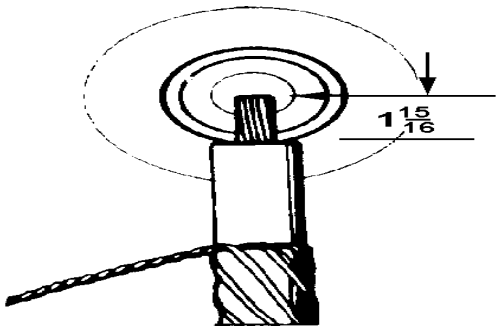



**Figure 4, 1-15/16” Of Insulation And Jacket Removed From Conductor**

**Step 3: Clean conductor.**

- Remove all loose insulation particles from bare conductors with a wire brush and immediately insert in connector barrel
- Remove dirt and oil from cable that can cause voltage to track across the different layers of the cable.

**NOTE:**
There are numerous methods and kits available for cleaning cable, one of these is the A-2 prep kit from Scotch 3M. This kit contains saturated cloths that can be used for cleaning the different layers of the cable.

**Step 4: Attach crimp connector.**

- Holding the contact barrel against the cable insulation, so that the open threaded eye faces the bushing when the cable is trained as instructed in step (1) above crimp the connector.
- Start the crimps at designated line of the connector barrel and rotate 90° at each successive crimp.

- Use care not to nick or cut the cable insulation.
- Smooth any sharp edges or ears from the crimping operation.

**NOTE:**
Before crimping, make sure the threaded hole at the top of the connector is properly lined up with the bushing on the transformer or other using equipment (Figure5). If not lined up correctly it will be difficult to seat the elbow on its bushing once it is completed. The hole must line up properly to allow the elbow to be installed without having to twist the cable.

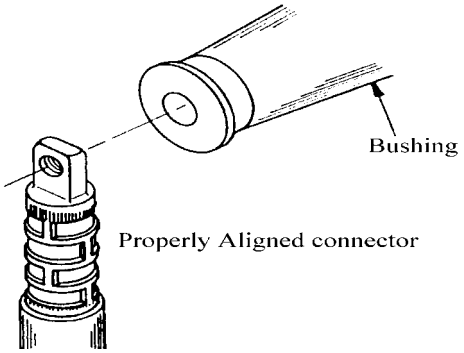



**Figure 5, Connector Alignment**

**Step 5: Remove outer jacket.**

- Carefully remove the outer semi-conductor jacket 6-½" back from the center line of the threaded connector eye using the template supplied (Figure 6).

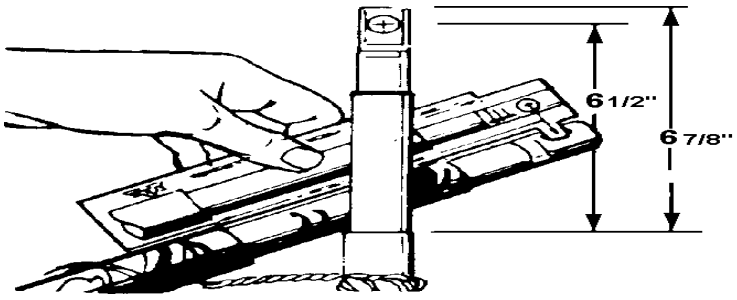



**Figure 6, Outer semi-conductor jacket removed**

- Use a clean rag and approved cable cleaner to completely remove all traces of dirt semi-conductive material, and connector inhibitor from the insulation and last 2" of cable semi-conductor jacket.

**Step 6: Lubricate cable.**

- Wipe a small amount of silicon grease supplied on the exposed cable insulation and in the cable entrance of the elbow before installing cable (Figure 7).

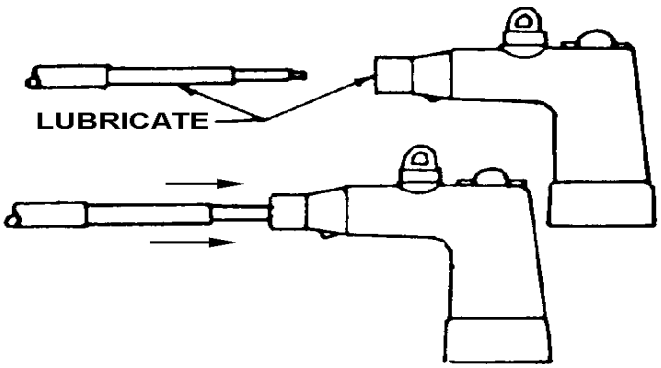



**Figure 7, Lubrication points**

- This lubricant is used to help the elbow slide easily over the cable end.

**Step 7: Install elbow.**

- Once the end of the cable is prepared it is necessary to position the elbow sleeve.
- Make sure you do not over stress or bend the cable while positioning the elbow.
- Push the cable into the elbow with the threaded connector eye facing the open bushing cavity.

- When the elbow is slid completely over the cable make sure to line the connector up inside the elbow so the electrode can be attached later.
- Use a clean dry rag to remove all excess silicon grease.

**Step 8: Attach threaded electrode.**

- After the elbow is positioned over the cable and the connector is aligned properly we can attach the threaded electrode.
- The threaded electrode is the piece that actually makes contact with the bushing of the using piece of equipment (transformer, switch, etc.).
- Insert the male contact and arc follower probe into the threaded connector eye.
- Engage threads and tighten the probe using the wrench supplied.
- Insert the short end of the wrench into the hole of the probe, as shown in figure 8, and tighten the probe until the wrench bends substantially and is permanently deformed. (A new wrench comes with each loadbreak elbow.)
- Once the electrode is tight the wrench is discarded.

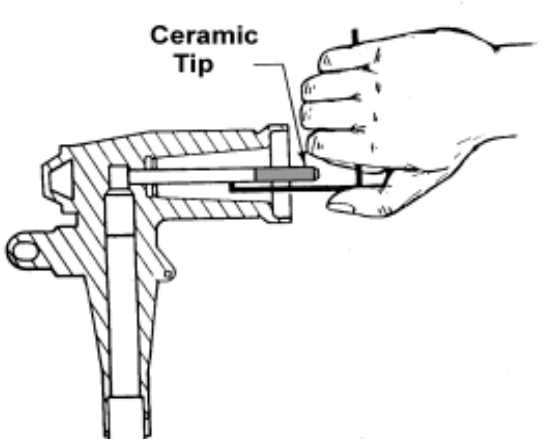



**Figure 8, Tightening Threaded Electrode**

**Step 9: Attach ground leads.**

- As with any type of cable termination a Loadbreak elbow must be grounded.
- Tie two strands of the concentric neutral through to the grounding eye of the elbow (Figure 9) and secure.

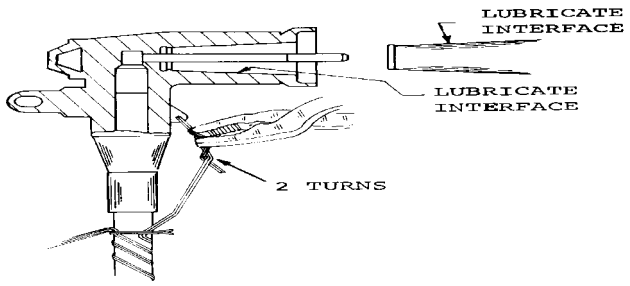



**Figure 9, Attaching Ground Strands**

- Take care not to damage the grounding eye on the loadbreak elbow when connecting concentric neutral wires.
- Tightly twist the strands at least two turns.
- Connect the remaining concentric neutral wires to the ground bus.

**Step 10: Install Elbow on bushing.**

- The final step in the process of completing a Loadbreak elbow is installing the elbow on the using piece of equipment.
- Lubricate the bushing, elbow receptacle and arc follower with lubricant supplied.
- Place the elbow firmly onto the bushing, making sure the elbow is lined up with the bushing to prevent misalignment of the probe and socket.
- Take care to assure the elbow is properly seated on the bushing.
- Lubricating the bushing during initial installation will make it easier in the future to remove the elbow assembly.
-

**SAFETY:**

**DURING SPLICING IT IS IMPORTANT TO BE AWARE OF YOUR SURROUNDINGS AT ALL TIMES, AND THE HAZARDS THAT MAY BE PRESENT. ALWAYS REMOVE JEWELRY BEFORE BEGINNING ANY WORK. MAKE YOURSELF AWARE OF ANY HAZARDS INVOLVED WITH THE CLEANING SOLVENTS. WHEN USING A KNIFE, ALWAYS CUT AWAY FROM YOURSELF AND REMEMBER TWO QUALIFIED PERSONS SHOULD ALWAYS BE PRESENT DURING ANY ELECTRICAL OPERATION.**

**NOTE:**

Following the instructions in the terminating kit will provide a more reliable connection. It also provides for ease of maintenance. You can find additional information on the Specification sheet for Loadbreak elbows.

# Review Questions
# for
# Fabricate Loadbreak Elbow

| Question | Answer |
|---|---|
| 1. What is the main purpose of a loadbreak elbow? | a. To provide a quick and easy way to test and isolate underground cable.<br>b. To insulate the termination point.<br>c. To reduce voltage drop at termination.<br>d. To prevent ground faults |
| 2. What is the primary difference of a loadbreak elbow compared to a bolt-on elbow? | a. The insulation value.<br>b. A ceramic tip on the threaded electrode.<br>c. The voltage capacity.<br>d. The size of the termination point. |
| 3. What is the most preferred tool for the removal of a loadbreak elbow? | a. A shorting stick.<br>b. A shotgun.<br>c. An elbow puller.<br>d. A loadbreak remover. |
| 4. All dirt and oil should be removed before attaching crimp connector. | a. True.<br>b. False. |
| 5. The concentric neutral wires run through the grounding eye must be tightly twisted at least _____ turns. | a. 1<br>b. 2<br>c. 3<br>d. 4 |
| 6. List the steps in the proper order for fabricating a loadbreak elbow. | a. Prepare cable<br>b. Attach ground leads<br>c. Train Cable<br>d. Attach threaded electrode |
| 7. The connector barrel must be rotated ____ degrees at each successive crimp. | a. 45 degrees<br>b. 60 degrees<br>c. 90 degrees<br>d. 180 degrees |
| 8. How much outer semi-conductor jacket is removed from the threaded connector eye? | a. 1 ¼”<br>b. 2”<br>c. 6 ½”<br>d. 6 ¼” |

**FABRICATE LOADBREAK ELBOW**

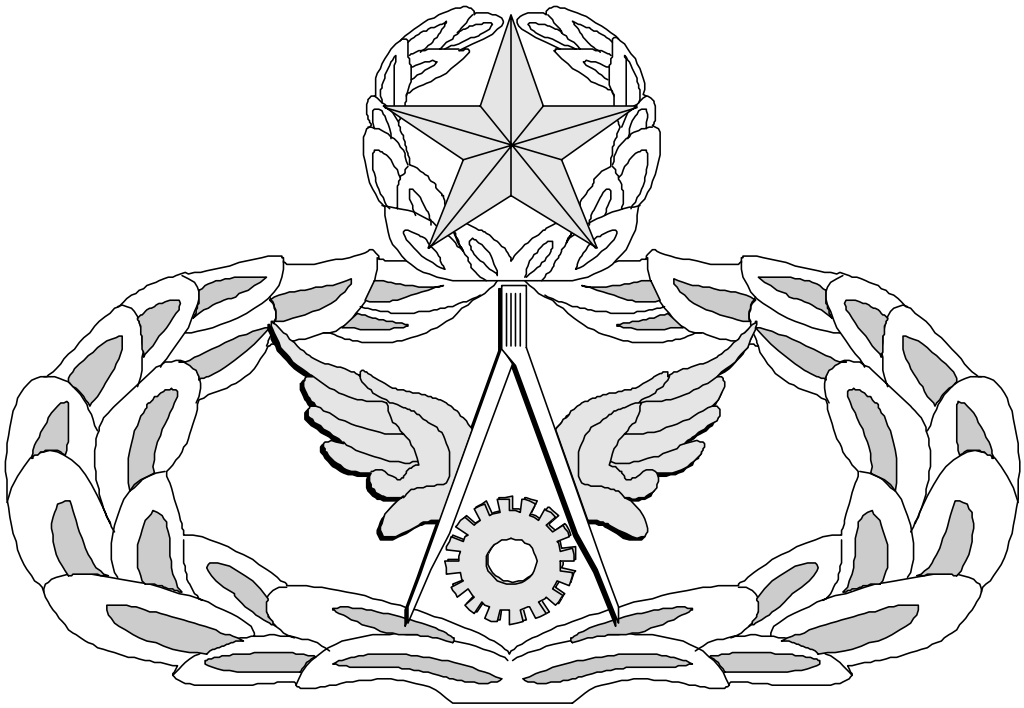
| Performance Checklist | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Did trainee utilize the template for preparing the cable end? | | |
| 2. Did trainee remove dirt and oil from conductor end? | | |
| 3. Did trainee properly align connector end with equipment bushing? | | |
| 4. Did trainee tighten electrode until enclosed wrench was bent? | | |
| 5. Did trainee make at least two turns on the ground attachment? | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

# Air Force Civil Engineer

## QUALIFICATION TRAINING PACKAGE (QTP)

## REVIEW ANSWER KEY



**For**

**ELECTRICAL SYSTEMS**

**(3E0X1)**

**MODULE 17**

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training if equipment is available. It is to be used in conjunction with these for training purposes only.

## DIRECT BURIAL CABLE

## (3E0X1-17.1.1.)

| Question | Answer |
|---|---|
| 1. What should be the first step in installing direct buried cable? | b. Run digging permit |
| 2. When using a trencher, what determines the width and the depth that the trench will be dug? | d. A and C |
| 3. The use of trenchers around power, phone fiber, and water lines are encouraged in rocky areas only. | b. False |
| 4. What installation equipment is used when multiple utility lines are installed in one trench? | d. Backhoe |
| 5. During installation worker should remain clear of _____, to prevent accidental injury. | d. All of the above |
| 6. All cable installations must be properly identified with marking tape. | a. True |

## PADS

## (3E0X1-17.1.3.1.)

| Question | Answer |
|---|---|
| 1. Transformer location should be as close to the facility for what reason(s)? | c. To help keep line loss and cost to a minimum |
| 2. What should be done to the lifting device prior to lifting the transformer? | c. Checked for proper weight capacity |
| 3. What should be checked after the transformer is placed on the pad? | c. The pad to ensure the pad did not settle unevenly |
| 4. What should be done after all connections are made to the primary and secondary? | a. Energize the transformer for testing |
| 5. What should be accomplished after the transformer is energized? | b. Check secondary voltage and phase rotation |

## INSTALL GROUNDING SETS
## (3E0X1-17.1.3.3.)

| Question | Answer |
|---|---|
| 1. The grounding conductor insulation is inspected for _____. | d. Cracked or splitting insulation and tight connections. |
| 2. What is used to clean the contact surfaces of the ground rod and the connector? | b. A wire brush. |
| 3. What is the grounding set connected to First? | a. The ground. |
| 4. If the ground rod is too cluttered or inexcessable, what is used as a ground point. | d. A temporary ground rod. |
| 5. How many sources can a feed through transformer be fed from? | c. 2 |
| 6. What is done after power has been isolated to a transformer? | d. You should check for voltage. |
| 7. On transformers with one input, what should be done with cables that have load-break elbows on them? | c. They should be removed and placed on parking bushings. |

## USING TAPE
## (3E0X1-17.3.1.)

| Question | Answer |
|---|---|
| 1. The goal of splicing cables is to connect two cable ends maintaining the cable's original _____ and _____ strength. | b. Mechanical, electrical |
| 2. Penciling of the primary insulation is key to providing smooth a transition from the original insulation and the insulation that will be applied. | b. False |
| 3. What is the junction point where the cable ends are connected? | d. A and B |
| 4. Most mechanical and hydraulic crimpers come with interchangeable ____, which are used to crimp various sized cables | c. Dies |
| 5. Only acid base flux will be used on high voltage splices. | b. False |

## TERMINATE HIGH VOLTAGE UNDERGROUND CABLE (3E0X1-17.4.)

| Question | Answer |
|---|---|
| 1. A termination is a/an _____ between the cable and the line equipment. | c. Transition |
| 2. Terminations are _____ for _____ | d. Choke points, the lines of flux |
| 3. When terminating cable about how many feet extra is left to do the termination? | b. 2 |
| 4. For a tape termination after setting the reference mark how many inches do you measure down the cable to remove the outer jacket? | d. 14 |
| 5. For a tape termination which tape is used to form the stress-cone? | a. #130 |
| 6. If the insulation is scared you should _____ it? | a. Sand and clean |
| 7. In the cold shrink type termination what is used to bond the termination to ground? | c. Both A and B |
| 8. What is done to the concentric neutral to add an extra measure of moister protection? | b. It is covered with tape. |

## ELECTRICALLY TEST UNDERGROUND CABLE (3E0X1-17.6.)

| Question | Answers |
|---|---|
| 1. Your safety zone should be at least _____ from any current carrying device. | c. 25 feet |
| 2. Prior to working on underground cables they must be _____ and _____? | a. Isolated and Grounded |
| 3. After Isolating cables _____ and _____the switches. | b. Lock, Tag-out |
| 4. Vehicles are not allowed inside of the safety zone. | b. False |
| 5. How do you prevent from getting false readings? | d. Isolate both ends of cable to be tested. |

## TROUBLESHOOT UNDERGROUND SYSTEM CABLES FOR FAULTS (3E0X1-17.7.)

| Question | Answers |
|---|---|
| 1. Before you attempt to troubleshoot an underground system, you must _____. | b. Isolate it from any source of power |
| 2. To find a fault in a cable, a _____is used. | c. megohmmeter |
| 3. What are Three types of faults cables are tested for are? | a. Opens, shorts and grounds |
| 4. Which meter is preferred when checking for opens. | a. Ohmmeter |

## TRACE UNDERGROUND CABLE WITH CABLE TEST SET (3E0X1-17.8.)

| Question | Answer |
|---|---|
| 1. When doing a battery check on the Metrotech 810, the needle should be to the left of the battery test line. | a. True |
| 2. The digital signal strength indicator should display _____ or above when doing a functional check of the receiver? | d. 950 |
| 3. How does the directional meter react when you move to the right of the transmitter center line? | a. Solid arrow and continuous tone. |
| 4. Any fluctuation in the meter reading during a conductive attachment test indicates ___? | b. A loose or broken wire within the conductor attachment. |
| 5. What is the name of the procedure(s) for locating underground cables? | d. All of the above. |
| 6. Connect the black lead of the transmitter to the targeted conductor when doing a direct (conductive) test. | b. False. |
| 7. How can conductivity be improved when using the ground plate? | c. Pour water under the plate. |
| 8. Place the transmitter over the conductor at least ____ feet away from where you will be searching with the receiver. | b. 100 |
| 9. When using the Indirect (inductive coupling with the Metroclamp) method, you must clamp below the electrical ground. | a. True |
| 10. When the receiver is directly above the conductor, what tone will you here? | a. Silence (no tone) |

## FABRICATE LOADBREAK ELBOW
## (3E0X1-17.10.)

| Question | Answer |
|---|---|
| 1. What is the main purpose of a loadbreak elbow? | a. To provide a quick and easy way to test and isolate underground cable. |
| 2. What is the primary difference of a loadbreak elbow compared to an elbow itself? | b. A ceramic tip on the threaded electrode. |
| 3. What is the most preferred tool for the removal of a loadbreak elbow? | c. An elbow puller. |
| 4. All dirt and oil should be removed before attaching crimp connector? | a. True. |
| 5. Ground thread attachments must be tightly twisted at least _____ turns? | b. 2 |
| 6. List the steps in the proper order for fabricating a loadbreak elbow. | a. Prepare cable<br>b. Attach ground leads<br>c. Train Cable<br>d. Attach threaded electrode |
| 7. The connector barrel must be rotated ____ degrees at each successive crimp. | c. 90 degrees |
| 8. How much outer semi-conductor jacket is removed from the threaded connector eye? | c. 6 ½” |